A

PRACTICAL TREATISE

ON THE

RAW MATERIALS AND THE DISTILLATION AND RECTIFICATION OF ALCOHOL,

AND THE

PREPARATION OF ALCOHOLIC LIQUORS, LIQUEURS, CORDIALS, AND BITTERS.

EDITED CHIEFLY FROM THE GERMAN OF

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PREFACE.

THE importance of the subject has claimed for the Distillation of Alcohol much scientific and practical investigation, both in this country and abroad, but being confined for the most part to elaborate and expensive works, or to the pages of periodicals, the result of this investigation is scarcely available to the large class interested in this branch of industry.

The chief object of this work is to supply those who are in any manner engaged in the distillation and rectification of alcohol, and the manufacture and sale of spirituous liquors, with a practical treatise on those subjects in a volume of small size and convenient arrangement, and within the means of all. This treatise is principally based upon the magnificent German work: *Die Branntweinbrennerei und deren Nebenzweige*, of Dr. Karl Stammer, which enjoys a well-deserved reputation in Germany and

France. But that book being too voluminous for the object in view, to allow of its being translated in its entirety, it has been my aim and study to select the portions of most practical value, and by condensing and combining them with material gathered from widely scattered sources, to produce a volume which, I believe, will furnish much useful information to those for whom it is designed.

In the numerous and valuable collection of receipts for the preparation of liquors, liqueurs, cordials, etc., which receipts have been mostly taken from the German work on that subject by Dr. F. Elsner, there will be found nothing but what is of practical value, most of them having been tested in Dr. E. Winkler's chemical laboratory in Offenbach-on-the-Main, before having been published in Germany.

W. T. B.

PHILADELPHIA, April 10, 1885.

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A

PRACTICAL TREATISE

ON THE

DISTILLATION AND RECTIFICATION OF ALCOHOL, ETC.

I.

ALCOHOL.

Properties of Alcohol.

In a general and practical sense, by *alcohol* is understood the spirit obtained by the distillation of fermented liquids, *i. e.*, mixtures of alcohol and water with small quantities of volatile aromatic substances.

Distillates intended for a beverage, and containing from 40 to 50 per cent. by volume of alcohol, are known by the general term of liquors, while those intended for other purposes, and containing up to and over 90 per cent. of alcohol, are termed spirit. Liquors are known, according to the material from which they are made, by the various names of brandy or cognac, rum, whiskey, gin, etc.

Although the commercial value of liquors intended for beverages is to a considerable extent determined by their flavor and taste, the intoxicating alcohol must be considered their most essential constituent. The principal consideration in the use of spirit is its percentage of alcohol. Spirit deodorized and deprived of its fusel oil by one of several processes, is known in commerce by the names of "pure spirit," "French spirit," etc.

Extensive and varied use is made of spirit in many branches of industry. It is employed for making liqueurs and various other spirituous liquors, for compounding wines, in the preparation of perfumes and varnishes, in the fabrication of vinegar, chemical and pharmaceutical preparations, and for many other purposes.

Spirituous liquors were known in the most remote times. In the eighth century impure spirit of wine was obtained by the distillation of wine. Raymond Lull, about the fourteenth century, was acquainted with spirit of wine, which he called *aqua ardens*, and made by distilling wine and concentrating the distillate by means of potassium carbonate. Lowitz subsequently succeeded in completely separating the water by means of quicklime. Lavoisier determined the constituents of alcohol, and Saussure their proportional quantities.

Pure or absolute alcohol consists of carbon, hydrogen and oxygen in a proportion expressed by the formula C_2H_6O, the composition in 100 parts corresponding to :

Carbon	52.17
Hydrogen	13.04
Oxygen	34.79

In the chemical sense, it belongs to a series of homologous bodies, the alcohols, which show a certain resemblance in regard to their chemical action.

Alcohol does not pre-exist in nature, but is a product of the decomposition of sugar.[1]

Fig. 1.

Pure or absolute alcohol is a colorless, very inflammable liquid of an agreeable reviving odor and pungent taste. Its specific gravity is 0.8095 at 0° C. (32° F.), 0.7947 at 15° C. (59° F.), 0 7939 at 15.5° C. (60° F.), and 0.792 at 20° C. (68° F.).

Alcohol has never been solidified. Faraday exposed alcohol to a temperature of 160° F. below zero; it thickened, but did not congeal. Hence the great use of spirit thermometers when a very low temperature is required to be noted.

Pure alcohol taken inwardly has

[1] M. A. Müntz, of the French National Agronomical Institute, announces that he has discovered traces of alcohol as a natural product in cultivated soil, rain-water, sea- and river-water, and the atmosphere. He has detected the product, it is true, only in the most infinitesimal quantities, but he has established the fact of its existence by analyses which are at once simple, clear, and convincing.—W. T. B.

a poisonous effect; injected into the veins it rapidly produces death. It can be mixed with water in all proportions, whereby much heat is developed and a diminution in volume takes place. This may be shown by mixing the two liquids in the apparatus shown in Fig. 1, which consists of a long glass tube, furnished with two bulbs on the upper end, and having the elongated neck of the higher bulb closed perfectly with a ground-glass stopper. The tube and lower bulb are filled with distilled water; when this is effected alcohol is poured in, till the upper bulb is filled; the stopper is next replaced, and the tube gently inverted. The two liquids now combine, and in the tube an empty space is visible, which, before combination, was completely filled. The space unoccupied shows the amount of contraction in bulk which has arisen from the combination of the alcohol and water; an elevation of temperature also takes place in consequence of the chemical combination and the diminished specific gravity of the mixture. Thus equal measures of alcohol of specific gravity 0.825, and water, each at 10° C. (50° F.), when suddenly mixed, rise to 21° C. (69.8° F.), and a mixture of equal parts of proof spirit and water at 10° C. (50° F.) gives, under like circumstances, a mixture having a temperature of 15.5° C. (60° F.). When alcohol and ice, or snow are mixed, the temperature is considerably reduced. Absolute alcohol, with a little more ice than it will

dissolve, reduces the temperature as low as —37.2° C. (—35° F.). Spirit of wine of 0.86 specific gravity and 16° C. (60.8° F.) mixed with snow at 0° C. (32° F.) is cooled down to —25.5° C. (—14° F.).

Alcohol dissolves resins, fats, volatile oils, ethers, alkaloids, many organic acids, and some of their salts. Iodine, bromine, phosphorus, and sulphur dissolve in alcohol, though the latter two only sparingly. Metallic carbonates and sulphates are not soluble in alcohol, though many chlorides and bromides are.

Alcohol boils at 78.3° C. (173° F.). It is very inflammable, and, when anhydrous, burns with a whitish flame, which deposits carbon on a cold surface held in it; when mixed with water the flame is quite blue and no deposit of carbon is formed. In the combustion of alcohol very little light is emitted, but intense heat is given off. The specific heat of alcohol is 0.615, *i. e.*, it requires, in order to heat it to a certain temperature, only $\frac{615}{1000}$ of the quantity of heat necessary to bring a like quantity of water to the same temperature. The quantity of heat required to heat 1 kilogr. (2.2 lbs.) of water 1 degree C. is called a *unit of heat.* Hence to heat 1 kilogr. (2.2 lbs.) of water from 0° to 100° C. 100 units of heat are required; but, on the other hand, to convert water of 100° into steam of 100°, 536 units of heat more are required, which, as they are not perceptible on the thermometer, are called *latent.* Hence to convert water of 100°

into steam of the same temperature, 5.36 times the quantity of heat is required with which the same quantity of water can be heated from 0° to 100° C.

Alcohol cannot be heated further than to 78° C. (172.4° F.), (we use this figure for the sake of brevity, instead of the above more accurate one), and hence only 78.0615 or 47.97 units of heat are required to bring 1 kilogr. (2.2 lbs.) of alcohol to the boiling point. The latent heat required to convert this amount of alcohol into vapor amounts only to $\frac{1}{2.55}$ of that for water, and therefore 208.9 units of heat are required to convert 1 kilogr. (2.2 lbs.) of boiling alcohol into alcoholic vapor.

Alcohol brought in contact with certain porous bodies, for instance spongy platinum, oxidizes slowly to aldehyde and acetic acid. Through the action of ferments or microscopical plants, alcoholic liquids oxidize also to dilute acetic acid or vinegar. Alcohol exposed to a red heat with exclusion of air decomposes, carbonic oxide, hydrogen, carbon, and hydrocarbons being formed.

In mixing alcohol with water a contraction, as stated above, takes place. It is greatest when 54 parts by volume of alcohol are mixed with 49.72 parts by volume of water, the mixture forming not 103.72 parts by volume, but only 100 parts, so that a contraction of 3.72 parts has taken place.

The greater the proportion of water the smaller the contraction; on mixing water and diluted alco-

hol, which has already suffered contraction, no further change in the volume takes place.

The following table shows the contractions in different proportions of mixtures, and their specific gravities.

Specific gravity.	100 measures contain measures of		Contraction.
	Alcohol.	Water.	
1.0000	0	100.000	0.000
0.9985	1	99.055	0.055
0.9970	2	98.111	0.111
0.9956	3	97.176	0.176
0.9942	4	96.242	0.242
0.9928	5	95.307	0.307
0.9915	6	94.382	0.382
0.9902	7	93.458	0.458
0.9890	8	92.543	0.543
0.9878	9	91.629	0.629
0.9866	10	90.714	0.714
0.9854	11	89.799	0.799
0.9843	12	88.895	0.895
0.9832	13	87.990	0.990
0.9821	14	87.086	1.086
0.9811	15	86.191	1.191
0.9800	16	85.286	1.286
0.9790	17	84.392	1.392
0.9780	18	83.497	1.497
0.9770	19	82.603	1.603
0.9760	20	81.708	1.708
0.9750	21	80.813	1.813
0.9740	22	79.919	1.919
0.9729	23	79.014	2.014
0.9719	24	78.119	2.119
0.9709	25	77.225	2.225
0.9698	26	76 320	2.320
0.9688	27	75.426	2.426
0.9677	28	74.521	2.521
0.9666	29	73.617	2.617
0.9655	30	72.712	2.712
0.9643	31	71.797	2.797

Specific gravity.	100 measures contain measures of		Contraction.
	Alcohol.	Water.	
0.9631	32	70.883	2.883
0.9618	33	69.958	2.958
0.9605	34	69.034	3.034
0.9592	35	68.109	3.109
0.9579	36	67.184	3.184
0.9565	37	66.250	3.250
0.9550	38	65.305	3.305
0.9535	39	64.361	3.361
0.9519	40	63.406	3.406
0.9503	41	62.451	3.451
0.9487	42	61.497	3.497
0.9470	43	60.532	3.532
0.9452	44	59.558	3.558
0.9435	45	58.593	3.593
0.9417	46	57.618	3.618
0.9399	47	56.644	3.644
0.9381	48	55.699	3.699
0.9362	49	54.685	3.685
0.9343	50	53.700	3.700
0.9323	51	52.705	3.705
0.9303	52	51.711	3.711
0.9283	53	50.716	3.716
0.9263	54	49.722	3.722
0.9242	55	48.717	3.717
0.9221	56	47.712	3.712
0.9200	57	46.708	3.708
0.9178	58	45.693	3.693
0.9156	59	44.678	3.678
0.9134	60	43.664	3.664
0.9112	61	42 649	3.649
0.9090	62	41.635	3.635
0.9067	63	40.610	3.610
0.9044	64	39.586	3.586
0.9021	65	38.561	3.561
0.8997	66	37.526	3.526
0.8973	67	36.492	3.492
0.8949	68	35.457	3.457
0.8925	69	34.423	3.423
0.8900	70	33.378	3.378
0.8875	71	32.333	3.333
0.8850	72	31.289	3.289

Specific gravity.	100 measures contain measures of		Contraction.
	Alcohol	Water.	
0.8825	73	30.244	3.244
0.8799	74	29.190	3.190
0.8773	75	28.135	3.135
0.8747	76	27.080	3.080
0.8720	77	26.016	3.016
0.8693	78	24.951	2.951
0.8665	79	23.877	2.877
0.8639	80	22.822	2.822
0 8611	81	21.747	2.747
0.8583	82	20.673	2.673
0.8555	83	19.598	2.598
0.8526	84	18.514	2.514
0.8496	85	17.419	2.419
0.8466	86	16.324	2.324
0.8436	87	15.230	2 230
0.8405	88	14.125	2 125
0.8373	89	13.011	2.011
0.8339	90	11.876	1.876
0.8306	91	10.751	1.751
0.8272	92	9.617	1.617
0.8237	93	8.472	1.472
0.8201	94	7.318	1.318
0.8164	95	6.153	1.153
0.8125	96	4.968	0.968
0.8084	97	3.764	0.764
0 8041	98	2.539	0.539
0.7995	99	1.285	0.285
0.7946	100	0.000	0.000

The boiling points of mixtures of alcohol and water lie between those of the two constituents (173° and 212° F.), it being the nearer to the one or the other limit, the more of the respective constituent the mixture contains. The vapors escaping in boiling have not the same composition as the mixture, but contain a greater proportion of alcohol.

Hence the percentage of alcohol is not constant, but decreases as the portion rich in alcohol escapes, until finally an entire volatilization of the alcohol present, and only of a part of the water, is effected, and pure water remains as a residue.

A mixture consisting, for instance, of 1 part of alcohol with 14 of water, *i. e.*, a fluid of 6.7 per cent., evolves, in the commencement of boiling, vapors containing 60 per cent. of alcohol. After the evaporation of $\frac{1}{5}\frac{}{0}$ of the volume of the fluid, the vapor contains 54 per cent., after the evaporation of $\frac{2}{5}\frac{}{0}$ 48 per cent., and so on.

The reverse takes place in fluids very rich in alcohol, for instance, such as contain only 2 to 3 per cent. of water. They yield at first vapors poor in alcohol, pure alcohol being only volatilized after some time.

The following table compiled by Gröning and completed by Otto gives the boiling points of different mixtures and the percentage of the escaping vapors. It is to be regretted that the table has not been carried out further, especially for the liquids poor in alcohol, as it would be desirable for the proper judging of many occurrences in the distilling process, to know the respective proportions for fluids with between 0 and 1 per cent. of alcohol.

TABLE I.

Percentage of alcohol in 100 parts by volume of the boiling fluid.	Boiling temperature (temperature of the vapor) C.	F.	Percentage of alcohol in 100 parts by volume of the condensed vapor.
90	78.8°	174°	92
80	79.4	175	90.5
70	80	176	89
60	81.3	178.3	87
50	82.5	180.5	85
40	83.8	183	82
30	85	185	78
20	87.5	189.5	71
18	88.8	192	68
15	90	194	66
12	91.3	196.3	61
10	92.5	198.5	55
7	93.8	201	50
5	95	203	42
3	96.3	205.3	36
2	97.5	207.5	28
1	98.8	210	13
0	100	212	0

Alcoholic liquids are formed from saccharine fluids by a peculiar process, called *fermentation*, of which we will speak later on. The liquids thus formed contain but a small percentage of alcohol, and, in order to make them richer, the above-mentioned properties of mixtures of water and alcohol are made use of, and alcohol of varying strengths prepared by *distillation*.

By repeated distillation a liquid containing 95 per cent. of pure alcohol can be obtained.

To produce pure anhydrous alcohol, the tendency

of substances such as quicklime, calcium chloride, potassium carbonate, anhydrous copper sulphate, etc., to withdraw water from liquids with which they are brought in contact, is taken advantage of. A retort is filled with fragments of burnt quicklime and spirit of 90 per cent. poured on to it. After standing for a day, it is distilled with the aid of a water bath; the distillate is nearly anhydrous; to remove the last traces of water it is necessary to leave it for some time in contact with caustic baryta, and to rectify it again.

The least trace of alcohol in an aqueous solution can be readily detected by adding to the liquid a little benzoyl chloride, which is slowly acted upon by water, but forms with alcohol at once, ethyl benzoate, a liquid having a very characteristic odor, and which will be readily perceived after the excess of the chloride has been destroyed by caustic potash. By means of this reaction the presence of 0.1 per cent. of alcohol in a few fluidrachms of water can be shown.

From what has been said in the foregoing, the principal parts of the execution of the distilling process can be readily distinguished.

The saccharine fluids are first subjected to fermentation under such conditions as to effect the utmost formation of alcohol. The resulting alco-

holic fluid is then distilled in such a manner, and as often as is necessary, to obtain a liquid of the desired strength.

The saccharine fluids used for fermentation are not, however, only such as are produced by nature, but some are also prepared by chemical processes from substances containing starch, and used in the same manner as natural ones.

Our principal task will therefore be the consideration of the production of alcoholic fluids from saccharine substances, and from such as contain starch, and next the process of gaining spirit from these fluids.

By allowing sugar solutions to ferment, the chief products will be alcohol and carbonic acid, the latter of which escapes. By distilling such fluid, pure spirit will be obtained in the distillate, and pure water in the residue. But as *pure* sugar solutions are never used in practice, the distillate as well as the residue consists of various substances, the first containing, besides alcohol, volatile substances developed during fermentation from the non-sugar substances, and the latter, besides water, all non-volatile substances contained in the materials used, or produced from their constituents during fermentation.

The residue thus composed is called *swill*, and the volatile substances mixed with the spirit *fusel oil*. The character of the latter differs according to that of the fermented material; it imparts to the

product of distillation certain peculiarities of taste and odor, which indicate its origin. In many cases these peculiarities are esteemed and valuable, and are retained in the spirit, while in others they constitute an impurity which must be removed before the spirit can be used for other purposes.

The process of removing the fusel oil is called rectification, and constitutes a special branch of the manufacture of spirit.

II.

ALCOHOLOMETRY.

THIS is the process of ascertaining the centesimal quantity of anhydrous alcohol in a spirituous liquid. It is generally accomplished by determining the specific gravity of the liquid, but it is in this case absolutely necessary that only alcohol and water should be present. The quantity of alcohol in spirit containing much volatile oil or saccharine matter, etc., cannot be at once found by its specific gravity.

It happens sometimes that only small quantities of the alcoholic fluid are at command. In such a case it is impossible to obtain a correct result by determining the specific gravity of the few drops of alcohol obtained by distillation. It is then safer to subject the alcohol to organic analysis by com-

bustion with oxide of copper, and to calculate the quantity of absolute alcohol from the resulting carbonic acid and water.

The basis of practical alcoholometry in Germany, England, Russia, etc., are the numerous experiments by Gilpin. He did not use absolute alcohol, which could not be prepared in his time, but a mixture of 89.2 parts by weight of alcohol and 10.8 parts by weight of water. Tralles completed Gilpin's work, and his tables are the ones now in use.

In France alcoholometry is based upon Gay-Lussac's experiments, the results of which have only been recently published, and have been examined and confirmed by a commission of the French Academy. Gay-Lussac's statements correspond with those of Gilpin. Of less importance for the present time are the experiments made by Richter, Lowitz, Meissner, Gouvenain, Delezenne, and others. Drinkwater's careful work, and also that by Fownes, only confirm the accuracy of Gilpin's results.

The percentage of absolute alcohol may be stated by one of two methods; namely, by weight or volume. Liquors being sold by measure and not by weight, the centesimal amount by volume is usually preferred. But as the bulk of liquids generally, and particularly that of alcohol, increases by heat, it is necessary that their reputed richness should have reference to some normal temperature. This standard, as fixed by Tralles, is 60° F.

The following table has been elaborated according to Gilpin-Tralles, and gives the specific gravity S of the spirit, in I *a* for a percentage of alcohol, increasing from $\frac{0}{0}$ to $\frac{0}{0}$, in I *b* for a percentage of alcohol increasing from ·/. to ·/. The temperature of the spirit has been taken at 60° F., and also that of the water, whose specific gravity shall be equal 1. For the alcoholometry the reverse value of the specific gravity $\frac{1}{S}$, the so-called specific volume V is of greater importance, hence its value has been added to the table.

By taking the specific volume or the specific gravity of a spirit at 60° F., the percentage of alcohol, the per cents. by volume (%) as well as the per cents. by gravity (·/.), can be readily seen from the table. The table is also sufficiently convenient to serve for the conversion of per cents. by volume (%) into per cents. by gravity (·/.).

TABLE.

Specific gravity (S) and specific volume (V) of spirit at 60° F.

I *a*. Percentage of alcohol according to per cents. by volume. %			I *b*. Percentage of alcohol according to per cents. by gravity. ·/.		
%	*S.*	V.	·/.	*S.*	*V.*
0	1.0000	1.0000	0	1.0000	1.0000
1	0.9985	1.0015	1	0.9981	1.0019
2	0.9970	1.0030	2	0.9963	1.0037
3	0.9956	1.0044	3	0.9944	1.0056
4	0.9942	1.0058	4	0.9928	1.0073
5	0.9928	1.0073	5	0.9912	1.0089
6	0.9915	1.0086	6	0.9896	1.0105
7	0.9902	1.0099	7	0.9880	1.0121
8	0.9890	1.0111	8	0.9866	1.0136
9	0.9878	1.0124	9	0.9852	1.0150
10	0.9866	1.0136	10	0.9839	1.0164
11	0.9854	1.0148	11	0.9826	1.0177
12	0.9843	1.0160	12	0.9813	1.0191
13	0.9832	1.0171	13	0.9800	1.0204
14	0.9821	1.0182	14	0.9788	1.0217
15	0.9811	1.0193	15	0.9775	1.0230
16	0.9800	1.0204	16	0.9763	1.0243
17	0.9790	1.0215	17	0 9751	1.0255
18	0.9780	1.0225	18	0.9739	1.0268
19	0.9770	1.0235	19	0 9727	1.0281
20	0.9760	1.0246	20	0.9714	1.0294
21	0.9750	1.0256	21	0.9702	1.0307
22	0.9740	1.0267	22	0.9690	1.0320
23	0.9729	1.0279	23	0.9677	1.0334
24	0.9719	1.0289	24	0.9664	1.0348
25	0.9709	1.0300	25	0.9651	1.0362
26	0.9698	1.0311	26	0.9637	1.0377
27	0.9688	1.0322	27	0.9622	1.0393
28	0.9677	1.0334	28	0.9607	1.0409
29	0.9666	1.0345	29	0.9592	1.0425
30	0.9655	1.0357	30	0.9577	1.0442
31	0.9643	1.0370	31	0.9560	1.0460
32	0.9631	1.0383	32	0.9544	1.0479

I *a*. Percentage of alcohol according to per cents. by volume. %			I *b*. Percentage of alcohol according to per cents. by gravity. ·/.		
%	*S.*	*V.*	·/.	*S.*	*V.*
33	0.9618	1.0397	33	0.9526	1.0498
34	0.9605	1.0411	34	0.9508	1.0518
35	0.9592	1.0425	35	0.9490	1.0537
36	0.9579	1.0440	36	0.9472	1.0557
37	0.9565	1.0455	37	0.9453	1.0579
38	0.9550	1.0471	38	0.9433	1.0601
39	0.9535	1.0488	39	0.9413	1.0623
40	0.9519	1.0505	40	0.9394	1.0645
41	0.9503	1.0523	41	0.9374	1.0668
42	0.9487	1.0541	42	0.9353	1.0692
43	0.9470	1.0560	43	0.9332	1.0716
44	0.9452	1.0580	44	0.9311	1.0740
45	0.9435	1.0599	45	0.9291	1.0763
46	0.9417	1.0619	46	0.9269	1.0789
47	0.9399	1.0639	47	0.9248	1.0813
48	0.9381	1.0660	48	0.9227	1.0838
49	0.9362	1.0683	49	0.9204	1.0864
50	0.9343	1.0703	50	0.9183	1.0890
51	0.9323	1.0726	51	0.9160	1.0917
52	0.9303	1.0749	52	0.9138	1.0943
53	0.9283	1.0772	53	0.9116	1.0970
54	0.9263	1.0795	54	0.9094	1.0996
55	0.9242	1.0820	55	0.9072	1.1023
56	0.9221	1.0845	56	0.9049	1.1051
57	0.9200	1.0870	57	0.9027	1.1078
58	0.9178	1.0896	58	0.9004	1.1106
59	0.9156	1.0922	59	0.8981	1.1135
60	0.9134	1.0948	60	0.8958	1.1163
61	0.9112	1.0975	61	0.8935	1 1192
62	0.9090	1.1001	62	0.8911	1.1222
63	0.9067	1.1029	63	0.8888	1.1251
64	0.9044	1.1057	64	0.8865	1.1280
65	0.9021	1.1085	65	0.8842	1.1310
66	0.8997	1.1115	66	0.8818	1.1340
67	0.8973	1.1145	67	0.8795	1.1370
68	0.8949	1.1175	68	0.8772	1.1400
69	0.8925	1.1204	69	0.8748	1.1431
70	0.8900	1.1236	70	0.8724	1.1463
71	0.8875	1.1268	71	0.8700	1.1494
72	0.8850	1.1299	72	0.8676	1.1526

I *a*. Percentage of alcohol according to per cents. by volume. %			I *b*. Percentage of alcohol according to per cents. by gravity. °/.		
%	*S.*	*V.*	°/.	*S.*	*V.*
73	0.8825	1.1332	73	0.8652	1.1558
74	0.8799	1.1365	74	0.8629	1.1589
75	0.8773	1.1399	75	0.8605	1.1621
76	0.8747	1.1433	76	0.8581	1.1654
77	0.8720	1.1468	77	0.8557	1.1686
78	0.8693	1.1504	78	0.8533	1.1719
79	0.8666	1.1541	79	0.8500	1.1753
80	0.8639	1.1577	80	0.8484	1.1787
81	0.8611	1.1613	81	0.8459	1.1822
82	0.8583	1.1651	82	0.8435	1.1855
83	0.8555	1.1689	83	0.8409	1.1892
84	0.8526	1.1729	84	0.8385	1.1926
85	0.8496	1.1770	85	0.8359	1.1963
86	0.8466	1.1812	86	0.8333	1.2000
87	0.8436	1.1854	87	0.8307	1.2038
88	0.8405	1.1898	88	0.8282	1.2074
89	0.8373	1.1943	89	0.8256	1.2112
90	0.8339	1.1992	90	0.8229	1.2152
91	0.8306	1.2040	91	0.8203	1.2191
92	0.8272	1.2089	92	0.8176	1.2231
93	0.8237	1 2140	93	0.8149	1.2272
94	0.8201	1.2194	94	0.8122	1.2312
95	0.8164	1.2249	95	0.8094	1.2355
96	0.8125	1.2308	96	0.8065	1.2399
97	0.8084	1.2370	97	0.8036	1.2444
98	0.8041	1.2436	98	0.8006	1.2491
99	0.7995	1.2508	99	0.7976	1.2537
100	0.7946	1.2585	100	0.7946	1.2585

Example.—What per cent. by gravity contains spirit of 36.4 per cent. by volume of alcohol?

Table I *a* shows:—

36 % corresponds to $V = 1.0440$.

37 % corresponds to $V = 1.0455$.

Difference of 1 % corresponds to difference of 0.0015.

Difference of 0.4 % corresponds to difference of $0.4 \times 0.0015 = 0.0006$.

Hence,

36.4 % corresponds to $V = 1.0446$.

Table I *b* shows:—

$V = 1.0042$ corresponds to 30 °/.

$V = 1.0460$ corresponds to 31 °/.

Difference of 0.0180 corresponds to difference of 1 °/.

Difference of 0.0004 corresponds to difference of $\frac{0.0004}{0.0018} = 0.21$ °/.

Hence,

$V = 1.0446$ corresponds to 30.2 °/.

And, therefore, 36.4 % is as much as 30.2 °/.

In the practical application of the preceding table when graduating the alcoholometer, it is requisite to have two liquids of standard strength and temperature. Distilled water may be one of these, and the other any alcoholic liquor, the percentage of which has been precisely determined, but it is necessary that both should be at 60° F. The level at which the instrument stands should be scratched on the stem, and the intermediate space accurately divided according to the strength of the liquid. In constructing the alcoholometer, it is essential that its stem should for ordinary purposes be as uniform as possible. Tubes which do not vary throughout their length more than one-thirtieth of their diameter may be used.

Gay-Lussac's instrument is like a glass hydrometer, the stem of which is divided into degrees like that of Tralles, to indicate the percentage of

alcohol by volume, but the temperature at which the graduation is made is 15° C. (59° F.), instead of 60° F., as the normal temperature of Tralles's tables. Water is taken as unity at this temperature. The stem of the instrument is divided from the point at which it stands in water into 100 divisions, so that each on the scale is equal to one per cent. of alcohol; the one-hundredth division indicates pure or absolute alcohol, while 0, or zero, equals pure water at 15° C. (59° F.).

The instrument, if immersed in an alcoholic liquor at 59° F., marks the strength by the number of degrees below the surface; thus, if the alcoholometer stands at 57 in a liquid at 59° F., such a solution contains 57 per cent. by volume of alcohol.

In consequence of the temperature 59° F. being taken by Gay-Lussac as the fundamental number for determining the relation, the percentage of alcohol, and the specific gravities are in a slight degree different from those of Tralles, but the variation is so minute that in practice it may be overlooked.

Baumé's areometer is so well known that it is not necessary to describe it, and we will only mention the principle upon which it is constructed. Dissolve 10 parts of sodium chloride in 90 parts of distilled water, and dip the glass areometer, provided on the bottom with a mercury ball, into the solution, mark the point to which it sinks 0; then place the areometer in distilled water and mark the

level at which the instrument stands, 10. Divide the portion between 0 and 10 into ten equal parts, and then divide the entire tube into such parts, and the areometer is ready for use.

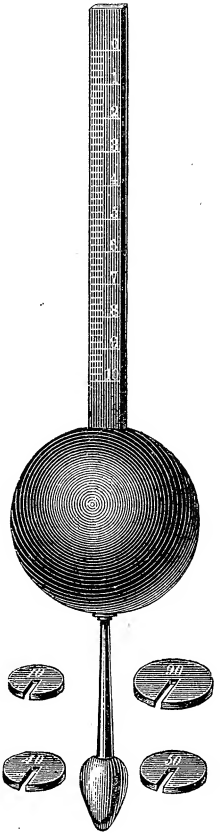
The following table gives the alternate relation of the degree of Baumé's areometer to the specific gravity of the liquid at a temperature between 13.5° and 15.5° C. (56.3° and 60° F.).

Degrees of Baumé's areometer.	Corresponding specific gravity.	Degrees of Baumé's areometer.	Corresponding specific gravity
50	0.782	29	0.884
49	0.787	28	0.889
48	0.792	27	0 895
47	0.796	26	0.900
46	0.800	25	0.906
45	0.805	24	0.911
44	0.810	23	0.917
43	0.814	22	0.923
42	0.820	21	0.929
41	0.823	20	0.935
40	0.828	19	0.541
39	0.832	18	0.948
38	0.837	17	0.954
37	0.842	16	0 961
36	0.847	15	0.967
35	0.852	14	0.974
34	0.858	13	0.980
33	0.863	12	0.987
32	0.868	11	0.993
31	0.873	10	1.000
30	0.878		

Fig. 2 represents Sikes's hydrometer, used in England to ascertain the real strength or percentage of alcohol. It is so arranged that the weight of

the replaced liquid is determined by means of weights. The instrument is of metal, and the stem is divided into ten divisions. Below the bulb is a thin stem upon which the nine weights (four of which are shown in the illustration), marked from 10 to 90, are placed; they correspond to the division of the upper stem.

Fig. 2.



When the instrument is dipped into an alcoholic liquor, the entire stem projects. It is pressed with the finger till sunk to 0, or zero, so as to wet the whole of the stem; from the resistance felt, experience teaches which weight will be required to append to it. After slipping on the weight, the instrument is again immersed in the liquid, and pressed with the hand till it has descended to 0 on the scale; the pressure of the hand is then withdrawn, and the instrument is allowed to emerge and settle at the proper point of the density of the liquid, as indicated by the scale and weights. The figure on the

scale to which the hydrometer sinks is now carefully observed, and the weight placed upon the lower stem added thereto; this sum will, by reference to the tables accompanying the instrument, give the percentage of alcohol. The strength is expressed in numbers, denoting the excess or deficiency per cent. of spirit in any sample. Three sliding rules which are used instead of the tables, likewise accompany the hydrometer. The exact temperature of the liquid should be taken previous to ascertaining the gravity, as the difference in temperature, if not corrected, would give as the result, a weaker or stronger liquor than if the thermometer stood at 60° F.

Dicas's hydrometer is used in America for testing distilled liquors; it is made of copper with a stem pointed on the summit to receive brass poises, and is accompanied by a graduated ivory scale, with a sliding rule and thermometer to make corrections for temperature. By this instrument the strength of the spirit is indicated, as with Sikes's hydrometer, by a certain number above proof.

In the distillation of spirit it is often necessary to reduce stronger alcoholic liquors to lower degrees of strength; and unless the amount of contraction which, as previously stated, takes place on mixing alcohol and water is known, considerable labor will be required to bring the mixture to the desired quality. The following table shows the

relative volumes of alcohol and water, which, when mixed, make up 100.

100 volumes of spirit contain at 15° C. (59° F.)		100 volumes of spirit contain at 15° C. (59° F.)	
Volumes of alcohol.	Volumes of water.	Volumes of alcohol.	Volumes of water.
100	0.00	45	58.64
95	6.18	40	63.44
90	11.94	35	68.14
85	17.47	30	72.72
80	22.87	25	77.24
75	28.19	20	81.72
70	33.14	15	86.20
65	38.615	10	90.72
60	43.73	5	95.31
55	48.77	0	100.00
50	53.745		

We give in the following a contraction of Gay-Lussac's table, which shows the per cent. of volume of water, which is to be added to a liquor, of whatever strength, to bring it to any degree of dilution. The upper horizontal column contains the per cent. of the stronger alcohol, and the vertical columns below, the bulk of water which is to be added to 100 volumes of it to produce spirit of the quality indicated in the left-hand column.

Desired strength in per cent.	100 Volumes of Alcohol of per cent. by Volume.								
	90.	85.	80.	75.	70.	65.	60.	55.	50.
85	6.56								
80	13.79	6.83							
75	21.89	14.48	7.20						
70	31.05	23.14	15.35	7.64					
65	41.53	33.03	24.66	16.37	8 15				
60	53.65	44.48	35.44	26.47	17.58	8.76			
55	67.87	57.90	48.07	38.32	28.63	19.02	9.47		
50	84.71	73.90	63.04	52.43	41.73	31.25	20.47	10,35	
45	105.34	93.30	81.38	69.54	57.78	46.09	34,46	22.90	11,41
40	130.80	117.34	104.01	90.76	77.58	64.48	51.43	38.46	25.55
35	163.28	148.01	132.88	117.82	102.84	87.93	73.08	58.31	43.59
30	206.22	188.57	171.05	153.61	136.04	118.94	101.71	84.54	67.45
25	266.12	245.15	224.30	203.53	182.83	162.21	141.65	121.16	100.73
20	355.80	329.84	304.01	278.26	252.58	226.98	201.43	175.96	150.55
15	505.27	471.00	436.85	402.81	368.83	324.91	301.07	267.29	233.64
10	804.54	753.65	702.89	652.21	601.60	551.06	500.59	450.19	399.85

III.

RAW MATERIALS.

I. *Saccharine Raw Materials.*

1. SUGAR. *a. Cane sugar* consists of:—

Carbon	42.1
Hydrogen	6.4
Oxygen	51.5
	100.0

This composition is expressed by the formula $C_{12}H_{22}O_{11}$. Sugar contains no water of crystallization. It occurs in the juices of many plants, in most sweet fruits, in the nectar of flowers, and in honey. In the greatest abundance it is found in sugar cane, *Sorgho saccharatum* (the Chinese or Asiatic sugar cane), in beet-root, in sugar maple, and several palm trees.

The specific gravity of cane sugar at 17.5° C. (63.5° F.) is 1.5813. It crystallizes in large colorless monoclinic prisms, and emits a phosphorescent light when broken in the dark with a hammer. In cold water, one-third of its weight is required for solution, but in boiling water it dissolves in any proportion. It is insoluble in absolute alcohol at an ordinary temperature, but is easily soluble in dilute alcohol, and the more so the more water the latter contains, the solubility increasing with the temperature.

Sugar melts at 160° C. (320° F.) to a clear liquid; when heated to 215° C. (419° F.) it loses water, and is converted into caramel, a brown, bitter, amorphous substance which is not fermentable.

The property of cane sugar to turn the plane of polarization to the right is made use of for the quantitative determination of sugar in solution, the angle of rotation being exactly proportional to the quantity of sugar contained in layers of equal thickness. The saccharometer of Soleil, an instrument in general use for this purpose, is provided with a graduated circle, divided in such a way that 100 divisions express the rotation caused by a plate of quartz of one millimeter (0.039 inch) in thickness. Now, as exactly the same rotation is produced by a layer of a solution of cane sugar having a length of 20 centimeters (7.87 inches) and containing 164.71 grammes (5.81 ozs.) of sugar in one liter (2.113 pints), it is only necessary, in order to ascertain the quantity of sugar in a substance, to dissolve 164.71 grammes (5.81 ozs.) in water, diluting to one liter (2.113 pints), and observing the rotation which it produces; the number of divisions being equal to the percentage of sugar.

By boiling sugar with acids or subjecting it to the action of ferments, such as yeast, it takes up one equivalent of water and is resolved into equal parts of dextrose and levulose. The solution of these two glucoses turns the polarized light to the left hand, the specific rotatory power of levulose

being greater than that of dextrose ; and a mixture of these two sugars is therefore called *inverted sugar*.

Pure sugar is scarcely ever used for the manufacture of alcohol, but materials of which it forms the chief constituent, such as molasses, sugar cane, etc., contribute a large quota to the manufacture of spirit.

b. Glucose and grape sugar. The variety of sugar known by this name is obtained from grapes, honey, etc., and for technical purposes, by the conversion of starch by means of acids or diastase. It crystallizes from an aqueous solution in cauliflower-like masses, and from hot alcohol in warty, anhydrous needles. The formula of glucose is $C_{12}H_{24}O_{12}$, or $C_6H_{12}O_6$, *i. e.* it contains one equivalent of water more than cane sugar, and in a crystallized state contains, besides, two equivalents of water of crystallization. To avoid confusion of ideas the following statements seem necessary: The word *glucose*, in this country, is employed among dealers to designate exclusively the thick syrup which is made from corn-starch. *Grape sugar* is applied to the solid product obtained from the same source. Glucose is a thick, tenacious syrup, almost colorless or of a yellowish tint. It has an average specific gravity of 1.412 at 20° C. (68° F.). That which is made for summer consumption is a little denser than that manufactured for winter use. This syrup

is so thick that, in the winter, it is quite difficult to pour it from one vessel into another.

The sweetness of glucose, *i. e.*, the intensity of the impression it makes on the nerves of taste, varies greatly with different specimens. Some kinds approach in intensity the sweetness of cane sugar, while others seem to act slowly and feebly. It has been shown that the degree of sweetness depends on the extent of the chemical changes which go on in the conversion of starch into sugar. When the process of conversion is stopped as soon as the starch has disappeared, the resulting glucose has a maximum sweetness. The color of glucose depends on the thorough washing of the substance, during the process of manufacture, through animal charcoal, and lowness of temperature at which it is evaporated, and rapidity of evaporation.

The grape sugar made from corn-starch, when well made, has at first a white color, but has a tendency to assume a yellowish tint when old. It is hard and brittle, does not usually take on a visible crystalline structure, and is less soluble in water than cane sugar. It is much less sweet to the taste than glucose, and a faint bitter after-taste is to be perceived.

Glucose melts at 170° C. (338° F.), losing water at the same time and being converted into *glucosan*, a colorless mass, which is scarcely sweet to the taste, and which by boiling with a dilute mineral acid is reconverted into dextrose.

By the action of certain ferments, glucose is readily converted into several products, the principal being alcohol and carbonic acid.

Both, glucose and grape sugar, are used in various fermenting industries, but not much in the distillation of spirit. Glucose is always found as an intermediate product where materials containing starch are employed for the manufacture of alcohol.

c. Levulose is a colorless uncrystallizable sugar of the same composition as glucose, from which it differs especially in its optical action, its solution turning the plane of polarization to the left. It is found in many ripe acid fruits, in the liquid part of honey, etc., and is formed, besides glucose, by the action of acid or yeast upon cane sugar, the product being always a mixture of both substances.

Levulose forms a colorless syrup of a sweet taste resembling that of cane sugar, and is soluble in water and in alcohol. It cannot be obtained in a crystallized form.

d. Inverted sugar has, like the two foregoing, the composition $C_{12}H_{24}O_{12}$. It is formed, as stated, by the action of yeast or acid upon cane sugar, and also occurs in some fruits. Inverted sugar consists of one atom each of glucose and levulose, its action upon polarized light being in consequence of this composition. It is syrup-like, and when allowed to stand exposed to the light, glucose in a crystalline form is separated. It is brought to fermentation by yeast.

Glucose, levulose and the mixture of both, inverted sugar, constitute therefore the actual material for fermentation. The chemical behavior of the three varieties of sugar differs but little, they being especially equivalent as regards the formation of alcohol. No difference is, moreover, made in practice, and, a misconception being scarcely possible, after what has been said, we will hereafter indicate all the mentioned sugars, *with the exception of cane sugar*, as glucose, or briefly as sugar. A more accurate distinction is of no special importance for the practical part of the distillation of spirit.

2. MOLASSES.—By this term is generally understood the brown, viscid, uncrystallizable syrup which drains off from sugar in the process of manufacture while cooling. It has a density of 82 to 86 per cent. (43° to 45° Beaumé), and contains from 16 to 19 per cent. of water.

The percentage of sugar in molasses varies between 46 and 53 per cent., being on an average about 50 per cent. Molasses from sugar houses, where great care is exercised in crystallizing the after-products, contains less.

The constituents of molasses, besides water and sugar, are manifold and partly not accurately known. By incineration 9 to 12 per cent. of mineral constituents are found, consisting principally of potassium, sodium, and lime combined with carbonic acid originating from organic substances; further, metallic chlorides, sulphates, etc. Potassium carbonate is always the principal constituent. Asparagin, betaïne,

ulminic, and huminic substances have been found among the organic substances; it contains, besides, nitrogenous and unknown acid-like combinations which form with potassium and sodium a kind of organic salts which produce, by incineration, the carbonates.

To find the composition of molasses as far as is of interest to practice, the water is determined by drying, or only approximately with the saccharometer, the sugar by polarization, and the mineral substances by incineration, the organic substances constituting what is missing.

The following figures were found in analyzing different varieties of molasses, and may serve to give a general idea of its composition:—

Water . . .	16.8	15.2	18.0	19.0	19.7
Sugar . . .	50.1	49.0	48.0	46 9	49.8
Foreign, organic, and mineral substances	33.1	35.8	34.0	34.1	30.5
	100.0	100.0	100.0	100.0	100.0

The following analyses enter somewhat more into details:—

Water	20.00	16.6	24.5	14.48
Sugar	52.73	50.1	43.5	64.21
Non-nitrogenous organic substances	9.18	13.5	13.3	
Nitrogenous organic substances	9.45	8.9	7.8	6.23
Nitric acid	0.18	—	—	—
Ash after deducting carbonic acid	8.46	10.8	10.9	9.88
	100.00	100.0	100.0	100.00
Percentage of nitrogen .	2.01	1.82	1.25	0.98

For the utilization of the swill, the composition of the mineral substances is of importance. We therefore give the following results of analyses of molasses:—

100 parts of ash gave :—					
Carbonic acid	28.90	27.94	28.70	26.11	30.84
Silicic acid	0.02	0.17	—	0.30	0.07
Sulphuric acid	1.33	1.52	1.41	1.89	2.15
Chlorine	6.05	8.16	6.97	7.69	10.42
Phosphoric acid	0.57	0.55	0.17	0.17	—
Ferric oxide	0.50	0.18	0.14	0.20	0.04
Alumina	0.17	0.11	0.53	—	—
Lime	5.04	3.60	3.12	3.39	15.16
Magnesia	0.18	0.10	0.18	0.32	—
Potassium	51.72	47.67	50.38	61.66	41.19
Sodium	8.00	11.43	8.29		
	104.28	101.43	99.89	101.73	99.87
Deduct for oxygen	1.36	1.84	1.37		
	101.12	99.59	98.52		

3. BEETS.—The beet belongs to the family *Chenopodium* and genus *Beta*. The two kinds most commonly cultivated are the red (*B. vulgaris*) and the white (*B. cicla*). The juice of these varieties contains, besides crystallizable sugar, albuminous substances, salts and extractive substances but incompletely known. The quantity of these constituents varies according to the variety and the manner of growth. In the manufacture of sugar from beets with an equally large absolute percentage of sugar, the yield depends on the proportion of sugar to the total quantity of the other constituents, while

the yield of alcohol depends solely on the percentage of sugar, and is not influenced by the foreign constituents. Hence the selection of the best beets is not of the same importance as for the manufacture of sugar, and beets which cannot be advantageously worked for sugar may give a paying yield of alcohol.

Composition of Beets.—The flesh of beets consists of a cellular tissue containing the juice in the form of a colorless liquid. The walls of the cells consist of cellulose, and are more or less coated with layers of a substance called intercellular substance, the principal constituents of which are pectine substances and tannin. The cellulose and intercellular substances constitute the pith (also called fibres), and form on an average about 4 per cent. of the weight of the beet.

The total quantity of substances held in solution in beet-juice varies considerably, it amounting generally to from 12 to 18 per cent. Hence the principal constituents of beets may be represented by the following figures:—

Dry substance 15.5 to 21	Undissolved cellulose, etc.	4.0 to 4.0	Pith.	
	Constituents held in solution . . .	11.5 to 17.0	Juice.	
Water		84.5 to 79.0		
		100.0	100.0	

According to chemical analysis, beet-juice contains the following substances: Crystallizable sugar, proteinaceous and nitrogenous bodies, potassium,

rubidium, sodium, calcium, magnesia, ferric and manganic oxides in combination with citric acid, oxalic acid, and other organic acids, as well as with such mineral acids as sulphuric, phosphoric, hydrochloric, and silicic acid; further, asparagin, betaïne, gum, fat, a colorless substance producing on exposure to air a brown coloring matter, and sometimes nitrates, and in colored beets, a coloring matter. All constituents, besides sugar, albuminous substances, and salts, are collectively called extractive substances.

For distilling purposes the determination of the density of the juice by Balling's saccharometer is generally sufficient, as from this a conclusion can be drawn in regard to the percentage of water, the total amount of substances held in solution, and the quantity of sugar. In special cases a more accurate determination of the percentage of sugar is necessary, which can only be effected by means of the polariscope. The most suitable method is as follows:—

Fill a small flask, graduated for 100 and 110 cubic centimeters, with the juice to be tested, to the 100 mark, and add vinegar of lead to the 110 mark, shake, and after allowing the mixture to stand for some time, filter, and observe in the polariscope. Add $\frac{1}{10}$ to the degrees read off and multiply with 0.26, which will give the weight of sugar in grammes contained in 100 cubic centimeters of juice, or in kilogrammes contained in a hectoliter of juice.

This determination suffices for most cases; it can also be directly used for the examination of every kind of beet-mash containing the sugar in its original form, and permits of an easy calculation of yield.

4. GRAPES. — In some countries, especially in France, the vine is extensively cultivated for the manufacture of cognac or spirit. The choice of vines is determined by the use for which the grapes are intended, the soil and the climate. For the production of alcohol it is of importance that the formation of sugar should be brought to its highest perfection, and as this can only be effected by prolonging the time of growth, the grapes are gathered as late as possible.

The sugar of the grape is a mixture of crystallizable grape sugar and uncrystallizable levulose in the proportion of about 75 : 25.

For the purpose of fermentation and distillation this mixture must be considered as equivalent to grape sugar. As the other substances contained in grape-juice exert no perceptible influence upon the density of the juice, the saccharometer can be used for testing it, Balling's giving the quantity directly in per cents.

The composition of the ash of grapes being of great importance for the culture of the vine, and for the utilization of the residue, we give in the following, the result of the analysis of the ash of four samples of juice:—

10,000 parts of juice contain :—

	I.	II.	III.	IV.
Potassium . .	17.18	22.12	29.39	18.19
Sodium . .	0.09	0.14	0.49	0.77
Lime . . .	1.34	1.14	1.39	1.48
Magnesia . .	0.86	1.61	1.63	1.15
Ferric oxide . .	0.19	0.15	0.03	0.12
Manganous oxide .	0.21	0.25	0.04	0.09
Phosphoric acid .	3.98	5.64	5.75	4.94
Sulphuric acid .	1.34	1.89	1.49	1.42
Chlorine . .	0.19	0.35	0.20	0.20
Silicic acid . .	0.52	0.71	0.49	0.60
	25.90	34.00	40.90	29.00

Potassium and phosphoric acid constitute therefore 80 to 85 per cent. of the ash.

1 liter (2.11 pints) of grape-juice contains on an average :—

860 to 830 grammes (30.33 to 29.27 oz.) of water.
150 to 300 " (5.29 to 10.58 ") " sugar.
30 to 20 " (1.05 to 0.705 ") " extractive or foreign substances, salts, acids, etc.

For the sake of completeness we give in the following a comparison of the percentage of constituents of several kinds of grape-juice :—

	I.	II.	III.	IV.
Sugar	13.780	10.590	13.52	15.14
Free acids	1.020	0.820	0.71	0.50
Albuminous substances	0.832	0.622		
Soluble pectic substances, gum, coloring matter, and fats	0.498	0.220	4.07	3.46
Ash	0.360	0.377		
Soluble substances	16.940	12.629	18.30	19.10
Seeds, Skin and cellular tissue	2.592	1.770		
Pectose	0.941	0.750		
Ash	0.117	0.077		
Insoluble substances	3.533	2.520	5.66	6.52
Water	79.977	84.870	76.04	74.38
	100	100	100	100

5. VARIOUS SACCHARIFEROUS RAW MATERIALS —*Fruits and Berries.*—Sweet fruits and berries yield an alcoholic distillate distinguished by its pleasant taste and aroma, but their utilization for the production of alcohol can only be advantageous where the conditions are such as to permit the use of materials poor in sugar, and a long time for fermentation.

We are indebted to Fresenius for an analysis of the most important varieties of fruits and berries, according to which :—

Plums,	contain	2.1	per cent.	of sugar.
Green gages,	"	3.1	"	"
Raspberries,	"	4.0	"	"
Huckleberries,	"	5.8	"	"

Currants,	contain	6.1	per cent.	of sugar.
Damsons,	"	6.2	"	"
Gooseberries,	"	7.1	"	"
Pears,	"	7.4	"	"
Apples,	"	8.4	"	"
Sour cherries,	"	8.8	"	"
Sweet cherries,	"	10.8	"	"
Grapes,	"	15.0	"	"

The percentage of sugar given is the average, as the sweetness of the same variety of fruit varies exceedingly according to circumstances.

Apples and *pears* are largely used for the production of brandy in Würtemberg and in Normandy.

Cherries yield the so-called cherry brandy, which is especially produced in the Black Mountains of Germany, in Switzerland, etc., the small black wild cherry, which excels in sweetness, being preferably used. The cherries are allowed to become very ripe and the stems are separated. In good years and dry gathering weather the juice of the cherries shows frequently 18 per cent. of sugar by the saccharometer.

Damsons and *plums* yield a brandy of a pleasant flavor, which is especially produced in Bohemia.

Huckleberries, *raspberries*, *blackberries*, and *elderberries* are used for the production of brandy in the Black Mountains.

SORGHUM.—The stalks of *Sorghum saccharatum*, *Holcus saccharatus*, have been frequently proposed

as a material for the production of alcohol. The contradictory statements about the variety of sugar contained in them are best explained by the fact that, when unripe, they contain only levulose, later on levulose and crystallizable sugar, and, when entirely ripe, only crystallizable sugar. The percentage of sugar varies from 6 to 15 per cent.

Moist heat seems to be necessary for the complete development of the sorghum plant. It is easily cultivated, and grows almost upon any soil. The seed is put in the ground as soon as all danger from frost is over. The stalk of completely grown sorghum is from 3 to 4 meters (9.84 to 13.12 feet) high. The crop is gathered when *the seed is completely ripe*, the observation of this being absolutely necessary, as the plant, when allowed to stand after the ripening of the seed, suffers injury from the attacks of the larvæ of an insect. Stalks piled up for any length of time lose a portion of their sugar; hence the crop should be quickly gathered and used at once.

Green corn stalks contain also sugar, and have been proposed for the production of alcohol.

The above-mentioned substances are by no means all the materials which can be used for the production of alcohol; but the advantageous employment of other substances than those mentioned depends so much on peculiar circumstances, and is so limited as to make a description unnecessary.

In conclusion, we would mention that the property

of cellulose of being converted into sugar by the action of concentrated sulphuric acid, and subsequent boiling of the mass with water has been utilized for the production of alcohol from wood (sawdust). Since the conversion in question requires a large quantity of sulphuric acid, this mode of obtaining alcohol must, in order to make it profitable, be combined with the manufacture of a product allowing of the utilization of the acid fluid before fermentation.

II. *Amylaceous Raw Materials.*

1. STARCH AND OTHER CONSTITUENTS OF GRAIN. *a. Starch* ($C_6H_{10}O_5$).—This important and widely-diffused body is found in large quantity in the seeds of the different varieties of grain, in leguminous plants, in chestnuts, potatoes, in the trunks of a number of pines, etc., in most roots, in a great many kinds of bark, even in fruits, for example, in apples. It is always deposited in plant cells, in the form of microscopic grains.

Technically it is prepared from wheat and potatoes by washing They are ground, and the starch grains washed out from the cellular substance in a fine wire sieve. The starch settles from the milky water as a white solid sediment, which is repeatedly stirred up with water, washed out, and finally dried in the air.

Starch is a soft, white powder, glistening in sun-

light, consisting of small, shining, transparent grains, recognizable under the microscope. The grains are formed of layers, arranged upon each other, surrounded by a more delicate and compact envelope, which is, perhaps, cellulose. The grains are of various sizes and forms, sometimes spherical, sometimes spheroidal, according to the plant from which they take their origin. The average diameter of the grains is, of—

	mm.	inch.
Potato starch . .	0.185	0.0072
Sago starch . . .	0.070	0.0027
Wheat starch . .	0.050	0.0019
Starch from *Chenopodium Quinoa* . . .	0.002	0.00079

Air-dried wheat starch contains, according to Balling, about twelve per cent. of moisture, and air-dried potato starch about 18 per cent. The moisture can be entirely expelled by continuous drying at 100° to 125° C. (212° to 257° F.).

Starch is tasteless, inodorous, and insoluble in cold water, alcohol, and ether, and is not acted upon by dilute acids and alkalies at an ordinary temperature. Treated with more concentrated acid (for instance, a mixture of 4 parts of sulphuric acid and 1 of water), it yields a transparent, intumesced mass. By the action of acids upon potato starch a peculiar odor is developed, which serves as an indication of the presence of this variety of starch.

When starch is heated with water to above 60° C. (140° F.) the envelopes of the granules are burst, and the starch forms a gelatinous translucent mass called "*starch paste*," that prepared from potato starch being more transparent than that from wheat starch.

A solution of starch heated with a concentrated infusion of malt* to 75° C. (167° F.), is first changed into an isomeric modification, called *soluble starch*, which is soluble in hot and cold water, and can be precipitated from its solution by alcohol. Iodine colors the solution blue, and baryta water gives a heavy precipitate. On continuing the heating of the solution, the soluble starch disappears, and the solution contains dextrine and grape sugar.

The conversion of starch can be readily followed with iodine solution. Immediately after soluble starch has been formed, iodine solution produces a blue coloring, but, on the heating being continued, it colors the liquid more and more reddish, and finally produces no coloring whatever. This is the moment when the soluble starch is completely converted into dextrine and grape sugar, both of which are not colored by iodine. The reddish coloring produced by iodine during the transforming process indicates clearly the formation of

* The Malt infusion is prepared by converting barley malt into a coarse powder, adding some cold water, and, after allowing it to stand a few minutes, filtering off the infusion.

another transitory product prior to that of dextrine of sugar from the soluble starch.

As malt contains starch, dextrine and sugar must also be formed when comminuted malt is treated with water at the mentioned temperature. This treatment of malt, or of malt and other amylaceous substances, with water at a temperature at which dextrine and sugar are formed (60° to 75° C., 140° to 167° F.), is called *mashing* or the *mashing process*, and the saccharine mass itself, the *mash.*

The conversion of starch into dextrine and sugar during the mashing process is effected by a constituent of malt known as *diastase*, readily soluble in water. Being only formed by germination, it is not present in unmalted grain. Hence unmalted grain contains only starch, which can be converted into sugar and dextrine, while malted grain contains starch and diastase, the sugar yielding and sugar forming substance. Diastase acts most vigorously between 60° and 75° C. (140° and 167° F.), and the more diastase (malt, malt extract) is present, the quicker the starch is converted. By heating to the boiling point, the diastase loses its efficacy.

Diastase is of a yellowish color, tasteless and friable, and, when roasted, diffuses an odor of toasted bread. It is very easily soluble in water, but insoluble in alcohol and ether.

b. Gluten; Diastase.—Next to starch, gluten con-

stitutes the greater part of the flour body of the seed of grain, and is contained, like starch, in the cells. It occurs in the form of organized granules, similar to those of starch, but smaller. When wheaten flour is made into a paste with water, and this is tied up in a cloth and washed with water as long as starch passes through, the gluten is left behind as an adhesive, elastic substance. It is very sparingly soluble in water, but readily so in acids not too much diluted. This latter point is of importance. Dilute alkalies exert also a dissolving influence.

Only gluten separated from wheat has thus far been thoroughly examined. That of rye, barley, and oats contains the same constituents, but in different proportions of weight. The gluten of rye flour is less elastic, more smeary, and, perhaps, richer in vegetable glue, while that obtained from barley flour is a grayish, not very adhesive mass, yielding, when treated with hot spirit of wine, much vegetable glue and caseine.

Gluten is of great interest for the fermenting process on account of the diastase being formed from it on germinating the grain during the malting process. From what part of the gluten the diastase is formed we do not know.

c. Diastase.—Pure diastase is never used in practice, but the malt itself, the starch contained in it being, in this case, also utilized.

Barley malt possessing the greatest power of

converting starch into dextrine and sugar, is preferred to the malt of wheat, rye, or oats, whose action, according to Balling, is less powerful.

One part of diastase is, according to Payen and Persoz, sufficient to convert 2000 parts of starch into dextrine and sugar.

d. Albumen.—On pouring cold water over ground grain or malt, the albumen dissolves with the other soluble substances, and is therefore contained in the filtrate. On separating starch and gluten from wheat flour, the albumen is found in the liquid standing over the starch. The most remarkable characteristic of albumen for our purposes is that it coagulates, or becomes insoluble, and separates in flakes when its solution is heated to about 85° C. (185° F.).

Albuminous fluids are not precipitated by small quantities of acids, the coagulation of the albumen on heating being even prevented by them.

Large quantities of acid, with the exception of acetic and phosphoric acid, form insoluble combinations with the albumen, which separate in flakes resembling coagulated albumen.

2. Grain.—The principal varieties of grain used for distilling purposes are rye and corn. Wheat, although used to some extent, is generally more expensive than rye, and its produce in spirit is not proportionate to its cost.

To judge of the value of a variety of grain for distilling purposes, a complete analysis is not

necessary, it being sufficient to know the quantity of extractive substances it is capable of yielding in mashing. The mixture of soluble substances obtained by the mashing process is called *extract* or *wort*, and consists of grape sugar and dextrine, some vegetable glue and the soluble constituents of the grain, and of those dissolved by the acid of the extract.

We are indebted to Balling for the following figures. The yield of extract (free from water) is from—

	Per cent.
Wheat	68 to 72
Rye	63 to 67
Barley	58 to 62
Oats	40 to 44
Corn	68 to 72

Balling gives, therefore, as an average for—

	Per cent. of extract.
Wheat	70
Rye	65
Barley	60
Oats	42
Corn	70

The quantitative chemical constitution of one and the same variety of grain varies very much; the climate, temperature of the year, the soil, and manure exerting an influence upon the quantity of

the constituents, and especially upon the proportion of starch and gluten in the flour body.

From 50 analyses Grouven gives the following as the average composition of wheat:—

	Per cent.
Starch and gum	63.3
Proteine substances	13.5
Fat	1.5
Salts	1.7
Cellulose	2.9
Water	14.1

Indian corn differs from wheat chiefly in containing considerably more fat (5 to 7 per cent.), and a smaller percentage of proteine substances. Fresenius found—

	Per cent.
Starch	65.9
Gum	2.3
Proteine substances	10.0
Fat	5.1
Cellulose	1.6
Ash	1.6
Water	13.5

As regards barley the statements as to the percentage of cellulose, and hence of starch, vary very much. The average may be given as follows:—

	Per cent.
Starch and gum	60
Proteine substances	10 to 12

Anderson found 7 to 11 per cent. of proteine substances, up to 70 per cent. of starch and gum, and only 8 to 10 per cent. of cellulose. Stein found 10.5 to 14.5 per cent. of moisture, about 55 per cent. of starch and gum, 3 per cent. of fat, 10.5 per cent. of proteine substances, 17 per cent. of cellulose, and 2 per cent. of ash.

Oats contain the largest quantity of hulls of all varieties of grain, the proportion of seed and hulls being as 70 : 30. The amount of starch and gum is from 40 to 44 per cent.

The quantitative chemical constitution of rye is similar to that of wheat, the average amount of starch being about 65 per cent.

All varieties of grain can be employed for the fabrication of liquors, the choice of the material depending chiefly on the aroma and flavor the resulting product is to have. For the production of alcohol the price of the material need only be taken into consideration. In many parts of Europe, for instance, alcohol can be produced cheaper from potatoes than from grain.

Wheat and spelt yield an excellent whiskey.

In regions where the cultivation of rye is largely in excess of that of wheat, the former is generally used as a material for distillation. Although the resulting whiskey has a somewhat harsher aroma and flavor than wheat whiskey, it is much liked.

Compared with the yield of alcohol, the price of oats and barley is generally too high to allow of

their being used as raw material. Malted barley is generally employed as the sugar-forming material in working other varieties of grain. Oats, which yield a pure whiskey of a very agreeable flavor, are sometimes used as an addition on account of the beards rendering the mash loose and easier to work. Barley is also sometimes used for the same purpose where wheat or rye malt is used as the sugar-forming substance; the general use of barley malt being chiefly due to the loosening effect it has upon the mash. It is further claimed that an addition of oats effects a more complete fermentation and imparts to the whiskey the property of pearling or foaming, which is considered a desirable quality.

Maize or Indian corn is extensively used for distilling purposes in the United States, Hungary, and Italy. As regards its chemical constituents it differs not from other varieties of grain. The heaviest corn is the best for distilling purposes. The average amount of moisture is 12 per cent., and that of starch 70 per cent. For other constituents see p. 73.

Rice, where the price will allow of its use, is a valuable material for the production of alcohol. Its qualitative composition does not vary essentially from that of grain, but the quantity of starch is greater. The composition of rice is as follows:—

	Per cent.
Water	5.0
Starch	83.0
Gluten	6.0
Woody fibre	4.8
Sugar, Dextrine	1.0
Oily matter	0.1
Mineral matters	0.1
	100.0

In mashing rice, Balling obtained 74 per cent. of mash extract, while Otto obtained 82 to 85 per cent. from rice flour; the residue of grains was 9 per cent.

3. POTATOES.—In many parts of Europe, potatoes, the tubers of *Solanum tuberosum*, form an important material in the manufacture of alcohol.

The average composition of potatoes is as follows:—

	Newly dug potatoes.	Potatoes dried at 100° C. (212° F.).
Water.	75.1	—
Albumen	2.3	9.6
Fatty matter	0.2	0.8
Cellulose	0.4	1.7
Salts	1.0	4.1
Starch	21.0	83.8
	100.0	100.0

They contain 28 per cent. dry substance, or 23 per cent. insoluble substance, and 77 per cent. of sap.

Potatoes raised in heavy soils in wet years are generally very watery; potatoes grown in light soil moderately manured are richest in starch. The riper the potatoes the less their percentage of water, and with equal ripeness, large potatoes are richer in water than small ones.

Fresenius and Schulze have proposed a convenient method to determine the percentage of starch and dry substance in potatoes. It is based upon the fact that a body floating in a fluid, *i. e.*, not remaining upon the surface nor sinking to the bottom, has the same specific gravity as the fluid itself. The specific gravity of a fluid in which a potato swims is therefore also the specific gravity of the potato.

Prepare a concentrated solution of common salt by pouring over a quantity of salt three times its weight of water, and filter the solution until it is entirely clear. Throw the potato to be tested, into a large beaker glass filled with water. The potato will sink invariably to the bottom because its specific gravity is greater than that of water. Now add gradually, with constant stirring, of the solution, of common salt until the potato remains suspended in any part of the fluid. Ascertain the specific gravity of the fluid as indicated on the scale of an accurate saccharometer, and the specific

gravity of the potato will be found in the following table:—

Saccharometer. Degrees.	Specific gravity.	Saccharometer. Degrees.	Specific gravity.
14.5	1.056	22.5	1.094
15	1.061	23	1.097
15.5	1.063	23.5	1.099
16	1.065	24	1.101
16.5	1.068	24.5	1.103
17	1.070	25	1.106
17.5	1.072	25 5	1.108
18	1.074	26	1.110
18.5	1.077	26.5	1.113
19	1.079	27	1.115
19.5	1.081	27.5	1.118
20	1.083	28	1.120
20.5	1.085	28.5	1.122
21	1.088	29	1.125
21.5	1.090	29 5	1.127
22	1.092	30	1.129

Suppose the saccharometer shows 24 degrees in the fluid, the specific gravity of the fluid, and hence of the potato, is 1.101. In case the saccharometer indicates 24.25°, the specific gravity would be between the figures 1.101 and 1.103, and, therefore, 1.102.

In making the experiment care should be had to remove the air-bubbles adhering to the depressions of the potato, which is best effected with a feather. By moistening the potato before placing it in the water, the formation of air-bubbles can be generally avoided. Care must also be had that in determining the specific gravity the fluid retains the same temperature it had during the suspension of the potato.

In the following table, calculated by Balling,

will be found the percentage of starch and dry substance in potatoes corresponding to the different specific gravities.

Specific gravity.	Percentage of		Specific gravity.	Percentage of	
	Starch.	Dry substances.		Starch.	Dry substances.
1.060	9.54	16.96	1.096	17.75	25.42
1.061	9.76	17.18	1.097	17.99	25.66
1.062	9.98	17.41	1.098	18 23	25.91
1.063	10.20	17.64	1.099	18.46	26.15
1.064	10.42	17.87	1.100	18.70	26.40
1.065	10.65	18.10	1.101	18.93	26.64
1.066	10.87	18.33	1.102	19.17	26.88
1.067	11.09	18.56	1.103	19.41	27.13
1.068	11.32	18.79	1.104	19.65	27.37
1.069	11.54	19.02	1.105	19.89	27.62
1.070	11.77	19.26	1.106	20.13	27.86
1.071	11.99	19.49	1.107	20.37	28.11
1.072	12.22	19.72	1.108	20.61	28.36
1.073	12.45	19.95	1.109	20.85	28.61
1.074	12.67	20.18	1.110	21.09	28.86
1.075	12 90	20.42	1.111	21.33	29.10
1.076	13.12	20.65	1.112	21.57	29.35
1.077	13.35	20.89	1.113	21.81	29.60
1.078	13.58	21.13	1.114	22.05	29.85
1.079	13.81	21.36	1.115	22.30	30.10
1.080	14.04	21.60	1.116	22.54	30.35
1.081	14.27	21.83	1.117	22.78	30.60
1.082	14.50	22.07	1.118	23.03	30.85
1.083	14.73	22.31	1.119	23.27	31.10
1.084	14.96	22.54	1.120	23.52	31.36
1.085	15.19	22.78	1.121	23.76	31.61
1.086	15.42	23.02	1.122	24.01	31.86
1.087	15.65	23.26	1.123	24.25	32.11
1.088	15.88	23.50	1.124	24.50	32.36
1.089	16 11	23.74	1.125	24.75	32.62
1.090	16.35	23.98	1.126	24.99	32.87
1.091	16.58	24.22	1.127	25.24	33.13
1.092	16.81	24.46	1.128	25.49	33.38
1.093	17.05	24.70	1.129	25.74	33.64
1.094	17.28	24 94	1.130	25.99	33.90
1.095	17.52	25.18	1.131	26.24	34.16

4. DIFFERENT RAW MATERIALS.— *Waste of starch factories.* In the manufacture of starch on a large scale by the ordinary process, a waste product of fibre containing starch is obtained, which, when well drained, amounts to from 70 to 72 per cent. of the potatoes and contains from 10 to 12 per cent. of dry starch substance. Where this fibre cannot be profitably utilized as cattle fodder, it can be used for the production of alcohol. By allowing the waste material to drain for 24 to 48 hours and then sprinkling with 2 to 3 per cent. of sulphuric acid diluted with twice its volume of water, and stamping solidly in pits, it can be kept for a considerable time.

Beans, *peas*, *lentils*, etc., though amylaceous substances, are not a paying material for the production of alcohol. The amount of starch varies between 30 and 40 per cent.; therefore considerably less than that of wheat and rye, while the amount of proteine substances (as much as 25 per cent.) is considerably larger.

Horse-chestnut (*Æsculus hippocastanum*).—Though horse-chestnuts contain a considerable quantity of starch, they cannot be obtained in sufficient quantities to make them available for the production of alcohol on a large scale, and a bitter substance they contain renders the residue useless for cattle fodder.

As horse-chestnuts soon mould when kept in a fresh state, they must be dried, ground and then mashed. Care must be had to remove the brown

hull and skin beneath it on account of their percentage of tannin which would injure or even entirely destroy the sugar-forming effect of the diastase; these precautions being also necessary in using acorns, which contain starch and sugar-yielding substances. The flour of horse-chestnuts is most advantageously used as an addition in mashing other materials. If saccharization is to be effected by sulphuric acid, the process is the same as for other amylaceous substances.

Jerusalem Artichoke (*Helianthus tuberosus*).—The tubers of this plant do not contain ordinary starch, but chiefly uncrystallizable sugar and an amylaceous secretion known as inulin, which is even more readily converted into sugar by diastase and acids than ordinary starch.

There are two varieties of *Helianthus tuberosus* distinguished by the different colors of the tubers.

Payen gives the following composition:—

Grape sugar	14.70
Inulin	1.86
Vegetable albumen	3.12
Cellulose	1.50
Pectine substances	1.12
Ash	1.29
Water	76.04

The soluble non-nitrogenous substances are converted into sugar by simple boiling. There has been a great variation in yield in consequence of

the varying composition. Generally speaking it may be assumed that the tubers of *Helianthus tuberosus* yield one-half more dry substance and sugar than beets, and leave behind about 50 per cent. of fodder.

Woody Fibre.—Woody fibre can, as is well known, be converted into grape sugar by boiling with concentrated sulphuric acid. Attempts to utilize this property by treating sawdust and other waste with acid, and fermenting the resulting saccharifierous solution, have not been sufficiently encouraging to make the process of any permanent technical value. This seems to be partly due to the great quantity of sulphuric acid required and the difficulty of removing it from the mass, and partly to the necessarily long duration of the action of the acid.

Lichens.—Large quantities of these plants occur in northern countries, especially in Sweden. Their cellulose possesses, according to Stenberg, the peculiarity of being quickly and completely converted into grape sugar by boiling with sulphuric or hydrochloric acid. Based upon these experiments several lichen distilleries have been established in Sweden, Norway, and Finland.

Several varieties of mosses, especially Iceland moss, reindeer moss, etc., are used. The composition of the latter is given as follows, by assuming that its cellulose is a substance differing from the ordinary cellulose and approaching starch. The

term amylo-cellulose has therefore been applied to it.

Water	9.5
Proteine substance	2.6
Fat	1.4
Ordinary cellulose	13.4
Starch and amylo-cellulose	72.1
Ash	1.0
	100

By treating the material with dilute acid, 68 to 73 per cent. of its weight of grape sugar is obtained.

The lichens (principally reindeer moss) are carefully gathered, and after drying, either pressed or ground to powder and stored for use.

5. AUXILIARY SUBSTANCES.—The most important of all other substances besides the actual raw materials used in distilleries is water. It will be readily acknowledged that on account of its chemical nature, water must exert a certain influence upon the success of the distilling operation, and hence it cannot be a matter of indifference what kind of water is used.

Generally speaking, water as pure as possible is the most suitable for distilling purposes. Lime salts, which render water hard, are especially injurious on account of increasing the labor of preparing the mash, and water containing large quantities of them should be entirely rejected and the preference given to river water if available.

It is claimed that a percentage of gypsum in the water has an injurious effect upon the process of fermentation, though there is no certain proof of it.

Water containing organic admixtures readily passing into a state of putrefaction or fermentation must be rejected as being injurious to a healthy and regular fermentation.

The temperature of the water requires also due consideration. *Cold* water is required for cooling artificial yeast and the water required for mashing must not exceed a certain temperature. For this reason the supply from running water will not suffice for distilleries carried on all the year round, and cold well water, or where that cannot be obtained in sufficient quantities, or cold enough, a well-filled ice house will be required.

Soft water only should be used for dissolving the sugar and diluting the spirit used in the manufacture of liqueurs, cordials, etc. Hard water must be rejected on account of the alcoholic fluid separating gypsum from it, which renders the resulting liqueur opalizing and turbid and difficult to clarify. The water should be colorless and free from all odor, and where the water is not entirely clear it is advisable to filter it before use.

We insert two tables showing the conditions of the pressure and temperature of steam, which will be found of use in the new mash process.

I.

Temperature.		Tension of the steam	
Degrees. C.	Degrees. F.	in atmospheres.	in pounds to the square inch.
100	212	1.000	14.10
105	221	1.193	16.82
110	230	1.415	19.95
115	239	1.670	23.55
120	248	1.962	27.67
125	257	2.295	32.35
130	266	2.671	37.66
135	275	3.097	43.64
140	284	3.576	50.42
145	293	4.113	57.99
150	302	4.712	66.44
155	311	5.380	75.85
160	320	6.121	86.30

II.

Tension of the steam in atmospheres.	Pressure of the steam		Temperature.	
	in pounds to the square inch.	in kilogr. to the square centimeter.	Degrees. C.	Degrees. F.
1.00	14.1	1.033	100.0	212
1.25	17.5	1.292	106.3	223.3
1.50	21.1	1.549	111.7	233.1
1.75	24.6	1.808	116.4	241.5
2.00	28.2	2.066	120.6	249.1
2.25	33.7	2.324	124.4	256
2.50	35.2	2.582	127.8	262
2.75	38.7	2.841	131.0	267.8
3.00	42.3	3.099	133.9	273
3.25	47.8	3.357	136.7	278.1
3.50	49.3	3.615	139.2	282.6
3.75	52.7	3.873	141.7	287.1
4.00	56.4	4.132	144.0	291.2
4.25	59.9	4.300	146.2	295.2
4.50	63.4	4.648	148.3	299
4.75	66.9	4.907	150.3	302.5
5.00	70.5	5.165	152.2	306
5.25	74.0	5.423	154.1	309.4
5.50	77.5	5.681	155.8	312.4
5.75	81.0	5.939	157.6	315.7
6.00	84.6	6.198	159.2	318.6

Some acids and salts, such as sulphuric acid, hydrochloric acid, carbolic acid, soda, and lime, are occasionally used in distilleries. These substances being the usual ones found in commerce, nothing need be said in regard to them except that their use should be as limited as possible with the exception of lime, and perhaps carbolic acid for cleansing purposes. In maize distilleries sulphuric acid and solution of sulphurous acid are sometimes used to which we will refer later on.

IV.

FORMATION OF ALCOHOL.

ALCOHOL is formed by the fermentation of saccharine liquids, or of mashes.

Saccharine raw materials can be immediately brought into fermentation, but with amylaceous substances the starch must first be converted into sugar, after which the conversion into alcohol is effected in the same manner as with saccharine materials.

The conversion of starch into sugar is effected by means of the diastase which forms an essential constituent of malt. Besides the conversion of starch into sugar, malt is of great importance to the distiller, as it constitutes the material for the preparation for yeast mash, which is much used as a substitute for the actual yeast.

Preparation of Malt.—The object of malting is to produce diastase by the germination of the grain. Barley is preferred for malting on account of its forming sugar in larger quantities than any other kind of grain. The germination of the seed takes place in three well-marked periods. In the first, the seed is enveloped in an outer organ which becomes exhausted and withered. In the second, the growth of the germ is shown by the swelling at the end by which it is attached to the stalk; and in the third period, the little plumule or

acrospire, which would form the stem of the new plant, is put forth. The germinating seed is similar to an egg, with its white, yolk, and embryo; the shell corresponds with the outer or hard coating of the seed, while the embryo of the egg has its analogue in the germ of the grain. A remarkable change takes place during germination; the glutinous constituent has passed from the body of the grain to the *radicula* or rootlet, which has grown to nearly the length of the grain, while about one-half of the starch has been converted into sugar. Malt intended for distilling purposes, or in other words, for its saccharifying capacity, should be grown a little more than malt designed for brewing purposes. In order to develop the diastatic properties, or the capacity for saccharification in malt, to its maximum degree, the rootlets should be allowed to attain a length of $1\frac{1}{2}$ times that of grain, while in malt calculated for the brewing of a pure malt beer, the rootlets have generally attained a length of only $1\frac{1}{3}$ times that of the grain.

For wheat, rye, barley, and oats, the most perfect germination takes place at a temperature of about 25° C. (77° F.), while the largest amount of diastatic properties is developed at a temperature of about from 15° to 20° C. (59° to 68° F.), and at this temperature the germination of such grains should be allowed to go on if they are to be used for distilling purposes. Corn and rice demand a

higher temperature, and corn must be steeped at least forty to fifty hours in water of 20° C. (68° F.) in order to be ready for the floors. The temperature of the low heaps should not exceed 30° to 35° C. (86° to 95° F.), and the corn should be allowed to grow until the acrospire has obtained four or five times the length of the grain. However, if the corn malt is to be mashed by itself, it is sufficient to let the acrospire attain three-fourths times the length of the grain; but even then a considerable amount of the starchy constituents must have been wasted, and it is difficult to see whence an increased yield should come.

The softening or steeping of the grain is accomplished in large cisterns of wood, sandstone, or cement, half filled with water. The grain is poured into the water, and after an hour or so sinks to the bottom of the tank, only the inferior and diseased seed remaining on the surface to be removed with wooden shovels. The steep-water withdraws from the grain extractive substances and becomes yellow, and, by the decomposition of the extracted substances, would soon turn sour and acquire a bad odor, if not removed and replaced by fresh water. How often this latter operation has to be repeated depends entirely upon circumstances, it being more frequently necessary in the commencement of the steeping process than later on. The duration of the softening varies according to the age of the grain, the temperature of the water, etc. A young fresh

grain requires 48 to 72 hours, while an older grain, containing more gluten, is not thoroughly softened under 6 or 7 days. Grains of equal age and constitution must be steeped together to obtain an equally softened product. The sufficiency of soaking is ascertained, 1. By pressing the grain between the finger and thumb-nail, when, if sufficiently moistened, the germ or embryo will be projected. 2. The husk is easily destroyed by pressure between the fingers. 3. When crushed with a piece of board, the grain yields a floury mass. The grain when softened has a peculiar odor resembling that of apples. The quantity of water absorbed by barley amounts to 40 to 50 per cent. of its weight, while the grain correspondingly increases in volume 18 to 24 per cent. During this absorption the grain loses 1.04 to 2 per cent. of its own weight in solid matter. 100 lbs. of grain require about 5 cubic feet steeping room.

After sufficient soaking the grain is allowed to drain for 8 to 10 hours, then taken out and thrown into heaps upon the floor of the malt-house. The chief art of the malster consists in stopping the germination at that point when the plumules and roots commence to draw upon the constituents of the grain. At first the barley is piled up in heaps from 12 to 16 inches high, and left in that position for 24 hours, when the surface will be so entirely freed from moisture that it does not feel damp. By degrees it becomes warm, its temperature being

5.5° C. (10° F.) above that of the atmosphere and it gives out an agreeably fruity smell. If at this time the hand is thrust into the heap it becomes bedewed with moisture. At this sweating stage the germination commences; the fibrils of the radicles shoot forth from the tip of every grain, and a white swelling appears which soon separates into three or more rapidly increasing radicles. About a day after this appearance, the plumula peeps forth from the same point, and would proceed under the husk until it appeared at the other end of the seed as a green leaflet; but this never happens in malting, as the operation is finished before it takes place. About 96 hours after the barley has been taken out of the steep the heat is greatest, consequently the radicles increase in length with great rapidity, and their growth must be checked by artificial means. This is effected by spreading the barley out thinner upon the floor and turning it several times a day, the interior being always brought to the surface by the shovels of the workmen. The depth of the heaps is slightly lessened at each turning, till it is at last not more than 3 to 4 inches.

To a limited extent the barley absorbs oxygen, and emits carbonic acid, just as animals do in breathing. The grain loses from $1\frac{1}{2}$ to 3 per cent. of its weight upon the malt floor, a portion of this being due to waste particles. As the acrospire creeps along the surface of the seed the constituents

undergo a remarkable change. The gluten and mucilage, in a great degree disappear, the color becomes whiter, and the substance so friable that it crumbles into meal between the fingers. This is the great object in malting, and is accomplished when the acrospire has reached the end of the seed. At this period the growth must be completely stopped. The duration of the germination may be between fourteen and twenty days, but the shorter the period between these limits the better, as there will be a quicker return of capital, and a superior malt produced.

Felted Malt.—Experience has shown that felted malt has advantages over the ordinary malt for distilling purposes, especially when it is to be used in a moist or green state, and its preparation requires less labor. But as only few distilleries have malthouses adapted for its preparation, its use is by no means as general as it should be.

The temperature for felted malt must be at least 15° C. (59° F.), and one or two degrees more would, with the moist air of the malthouse, be still better.

When the barley has been taken from the steep it is piled in a heap 30 centimeters (11.81 inches) deep, and turned over with the shovel every 6 to 8 hours until the exterior of the grain appears entirely dry. When this is accomplished the barley is allowed to rest until the fibrils of the radicle commence to show at the tip of the grain ; the barley

is then spread out in a heap 10 centimeters (3.93 inches) deep. This heap is allowed to rest until the radicles have grown into each other; this is called felting the malt. Should the upper layer of the heap become too dry, before the lower layer is thoroughly felted, it is advisable to sprinkle some lukewarm water over it before turning the heap.

The turning of the heap is effected with a flat, sharp, wooden shovel. The malt is spaded into large square sections, each section being turned separately. The grains of malt falling off in spading are either brought into a heap by themselves, or used for filling up the intermediate spaces caused by turning the heap. How often the malt has to be turned depends on the degree of felting; the proper period of turning has arrived when the lower layer has felted stronger than the upper.

Felted malt, whether it is to be used in a green state or converted into air-dried or kiln-dried malt, must be previously torn apart, which is best done by the use of a machine for the purpose. The machine is very simple and inexpensive. An oaken roller about 15 to 20 centimeters (5.9 to 7.87 inches) in diameter, and 40 to 50 centimeters (15.74 to 19.68 inches) long, and furnished with wooden or iron axles, rests in brasses which are fastened to a strong oaken frame, provided with legs. The roller is studded with sharp iron spikes about four centimeters (1.57 inch) long, and moved by means of a crank. Over the roller, somewhat inclined to the

side, is a hopper, which is fastened to the frame in such a manner that its lower part almost touches the iron spikes. The top of the hopper may be as wide as desired, but it must contract towards the bottom so as to leave only a slit 8 to 10 millimeters (0.31 to 0.49 inch) wide. The pieces of felted malt are thrown into the hopper, and, pressing towards the lower part, are caught, as soon as the roller is set in motion, by the spikes, and torn asunder. The malt falls into a box placed under the machine.

We have previously stated that it would be advantageous to use the malt in a green state. As this, however, cannot be done in most cases, it must receive a certain degree of drying, and the less it is dried the greater is the danger incident to the presence of the germs of fungi which in the course of a little time may produce an extended and dangerous fungus growth. In order to prevent this, it has been recommended to soak the barley, right after steeping and just before placing it upon the floors, for some time in a solution of one part of salycilic acid in 6000 parts of water. This is said to effectually destroy all fungus growth which may adhere to the barley, and to enable the green malt to be stored for some length of time without damage. We do not counsel a prolonged storage of green malt, but rather advise, where it cannot be used at once, a sufficient degree of drying in order to insure its keeping qualities.

When the germinating process is finished the grain is taken to the drying floor, where it is exposed to the air in layers 3 to 5 centimeters (1.18 to 1.96 inch) deep, and turned over with rakes 6 or 7 times daily. When the malt becomes dry it is cleared from the rootlets, some of which drop off by themselves, while others have to be removed by winnowing. For ordinary distilling purposes this drying suffices, but if the malt is to be used for brewing beer, or is to be kept for a long time, it has to undergo a roasting process. This drying or roasting is effected in a malt kiln or cylinder heated by flues to the boiling point of water. The malt kilns consist essentially of the drying plates upon which the malt is laid and the heating flues. The plates were formerly only made of stone or sheet iron, but in modern kilns wire-woven frames are used. They are placed one above the other so that the hot air from the flues beneath may ascend through the interstices. The flues are generally of sheet iron for the better conduction of heat to the surrounding atmosphere. Coke is used as fuel on account of the absence of smoke, as with coal or wood in the event of a leakage in the flues considerable damage would be done to the malt.

100 parts of barley give 92 parts of air-dried malt. The loss of 8 parts may be thus accounted for.

	Parts.
In the steep water	1.5
During malting	3.0
During germination . . .	3.0
Other losses	0.5
	8.0

The moisture in air-dried malt amounts to 12 to 15.2 per cent. which is expelled during the kiln drying. According to C. John, 100 parts of dried barley give :—

	I.	II.
Malt	83.09	85.88
Plumules . . .	3.56	3.09
Rootlets . . .	4.99	4.65
Fermentary products .	8.36	6.38
	100.00	100.00

Fermentation.—A small quantity of yeast mixed with a dilute solution of sugar produces gas bubbles, setting the liquid in motion and covering its surface with froth. Carbonic gas is developed, and the sweet taste of the solution is replaced by one derived from the alcohol in the solution. When the development of gas has ceased and the liquid becomes again clear, it will be found that the sugar has entirely disappeared, and been replaced by an exact proportion of alcohol and a smaller quantity of other substances. Besides these, the liquid contains carbonic acid in solution.

The liquid is now attenuated, and the chemical activity, which has brought it from the original state into this, is called *alcoholic* or *vinous fermentation*. The alcohol can, on account of its greater volatility, be separated from the liquid by distillation. The yeast will be found to have exhausted all its fermenting capability.

If a solution of sugar, which besides sugar contains certain nitrogenous and mineral combinations, such as malt extract, grain mash, beet juice, etc., is subjected to fermentation, there will be found, besides the dead and inactive yeast, newly formed yeast capable of exciting fermentation. The fermentation of such liquids is in fact the source of yeast.

It has been definitely established that the spores of yeast are universally diffused through the air, and that as soon as they meet with a solution containing the nutriment necessary for their development, yeast cells are produced and fermentation sets in. If air be excluded from grape juice or any saccharine solution, no fermentation takes place. Fresh grape juice may be kept for years at the temperature of 20° C. (68° F.) without undergoing any change, provided it does not come in contact with the atmosphere, or, if the air has been heated to redness, it may remain in contact with a saccharine liquor for an indefinite time without producing fermentation. But, as Pasteur has shown, the motes floating in the air can be collected in cotton

or asbestos placed in a tube through which air has been drawn; and a piece of this cotton or asbestos, placed in a sugar solution, which has been well boiled, and cooled again, but which contains the albuminoidal and mineral constituents of yeast, develops fermentation. Sugar solutions containing the same yeast constituents, but without this air dust, undergo no alterations, neither do those in which cotton or asbestos alone is introduced. The same liquid remains unaltered if it has been boiled in a glass flask, the neck of which is so bent that dust cannot fall into it.

To determine the chemical composition of yeast, all foreign bodies mechanically mixed with it must be first separated. By repeated washing, ammoniacal salts, acetic acid, and lactic acid are first removed, and the solid bodies falling either to the bottom or floating upon the surface, while the yeast distributes itself in the liquid. Yeast thus purified forms, after drying, a white powder without odor, and after removing the aromatic and fatty substances by washing with alcohol and ether, is without taste, while the cells appear to have suffered no alteration.

Yeast purified in this manner as much as possible from foreign substances still contains from 2.5 to 5.3 per cent. of ash, 100 parts of which are composed of:—

	Parts.
Phosphoric acid . . .	53.0 to 59
Potash	39.5 to 28
Magnesia	6.0 to 8
Lime	1.0 to 4

Dried and purified yeast contains, according to the experiments of several chemists, the following constituents:—

	Mulder.	Mits-cherlich.	Dumas.	Schlossberger.		Wagner.	
Carbon	50.80	47.0	50.6	49.53	47.59	49.71	44.59
Hydrogen	7.16	6.6	7.3	6.61	6 47	6 80	6.04
Nitrogen	11.08	10.0	15.0	11.97	9.78	9 17	9.25
Sulphur	30.96	0.6	27.1	31.89	34.32	34.32	40.12
Oxygen		35.8					

The cells are composed of:—

Carbon	44.6
Hydrogen	6.3
Oxygen	49.1

The contents of the cells form an albuminous substance composed of:—

Carbon	53.3
Hydrogen	7.0
Nitrogen	16.0
Oxygen	23.7

Yeast in a moist state exposed to the air rapidly decomposes and produces products similar in nature to those produced by the proteine bodies.

After drying at 100° C. (212° F.) yeast is still capable of exciting fermentation, but by heating the liquid in which it is suspended, to the boiling point, it is completely killed. Free mineral acids, such as hydrochloric acid, sulphuric and nitric acids, as well as free alkalies, stop fermentation, the latter only until their neutralization by the free carbonic acid. Organic acids injure fermentation only when very concentrated; in a dilute solution they seem to promote fermentation. Fermentation is also stopped or retarded by empyreumatic substances, essential oils, creosote, carbolic acid, prussic acid, concentrated alkaloids, and strong alcohol.

The conditions required for alcoholic fermentation may be summed up as follows:—

1. An aqueous solution of sugar in the proportions of 1 part of sugar to 4 to 10 parts of water. The sugar can be employed as grape sugar, dextrose, or levulose, which is always capable of fermentation; or an unfermentable sugar, cane sugar or sugar of milk, may be converted by means of acid or a suitable agent into fermentable sugar. However gradual the process may seem, cane sugar is always converted into grape sugar before fermentation.

2. The presence of yeast or spawn. In the first case, 1 part of yeast to 5 parts of sugar is sufficient to effect a strong fermentation. If spawn only is present, there must also be present substances upon which the spawn may feed or develop—protein subtances, phosphoric acid, humus,

and alkalies. If no ferment exists, the only other condition under which fermentation is effected is by exposure to:—

3. The atmosphere which introduces the beforementioned ferment and furnishes life.

4. A known temperature, the limits of which are 5° and 30° C. (41° and 86° F.). As a rule vinous fermentation is effected between 9° and 25° C. (48.2° and 77° F.). The lower the temperature the longer the time required for the fermentation to subside, and conversely. At 30° C. (86° F.) and a higher temperature, the vinous fermentation easily goes over into butyric acid fermentation.

Products of Fermentation.—If alcohol and carbonic acid were the only products of fermentation, the process might be represented by the following equation:—

$$\underset{\substack{180\\ \text{parts by weight}\\ \text{of grape sugar}}}{C_6H_{12}O_6} = \underset{\substack{92\\ \text{parts by weight}\\ \text{of alcohol}}}{2(C_2H_6O)} + \underset{\substack{88\\ \text{parts by weight}\\ \text{of carbonic acid}}}{2CO_2}$$

If crystallized sugar had been exposed to the action of a ferment, the process would be preceded by an absorption of water, and the equation would be: $C_{12}H_{12}O_{11} + 2O\ 4(C_2H_6O) + 4CO_2$.

According to this, 100 parts of grape sugar would yield 51.1 parts of alcohol, and 48.9 parts of carbonic acid, and 100 parts of cane sugar 53.8 parts of alcohol and 51.5 parts of carbonic acid; the latter after an absorption of 5.3 parts of water.

But the process is not as simple as this, succinic acid and glycerine being also products of alcoholic fermentation, as has been proved by Pasteur. Many methods may be used to prove the formation of succinic acid. One of the simplest is to evaporate the fermented liquid after having filtered it to separate the yeast, and then to heat the residue several times with ether which is afterwards allowed to evaporate spontaneously. In the course of a day or two, the sides of the glass are seen to be covered with crystals of succinic acid. At the bottom is a syrupy liquid full of the same crystals; this consists almost entirely of glycerine saturated with succinic acid. This process is not admissible for extracting and estimating succinic acid, but will serve to prove its presence in all fermented liquors, whatever may be their nature and origin.

Glycerine may be detected in almost the same way, but in place of ether, it is better to exhaust the residue with a mixture of alcohol and ether. This mixture dissolves the succinic acid and glycerine, and leaves behind the nitrogenized matter. The ethereal and alcoholic solution is concentrated, saturated with lime, and then evaporated to dryness. The residue is again treated with the mixture of alcohol and ether, which now only dissolves the glycerine, and leaves the succinate of lime.

This formation of succinic acid and glycerine explains the smaller yield of alcohol and carbonic

acid actually obtained, as compared with that calculated according to the above equations.

4 to 6 per cent. of the weight of the sugar is not reduced to the two principal products, but breaks up, under the absorption of the elements of water, into other products which pass either into solution, or are absorbed by the yeast. The proportion of the products varies, the following figures giving only an approximate value:—

	Parts.
Succinic acid . . .	0.6 to 0.7
Glycerine	3.2 to 3.6
Carbonic acid . . .	0.6 to 0.7
Cellulose and other solid substances (Pasteur) .	1.2 to 1.5
	5.6 to 6.5

The remainder breaks up into alcohol and carbonic acid according to the above formula.

The above-mentioned products are never absent, but their quantities vary with the amount of yeast and sugar employed.

From the figures given it is difficult to calculate the yield, which a given quantity of grape sugar, cane sugar, or starch, with a complete attenuation of the first, and perfect conversion of the last into grape sugar, can produce.

This yield is the *theoretical yield.* By assuming an average of 5 per cent. of the above proportion,

as the portion of sugar withdrawn from fermentation, there remain of 100 kilogr. (220 lbs.) of grape sugar, 95 kilogr. (209 lbs.), which, according to the equation, break up into alcohol and carbonic acid. They yield, as can be readily calculated, 48.5 kilogr. (106.7 lbs.) of absolute alcohol, or, as 1 liter (2.113 pint) of pure alcohol weighs, at the normal temperature, 794 grammes (28.02 ozs.), 61.1 liters (16.14 gallons) of pure alcohol of 100 per cent. or 61.10 liter per cent. For all practical calculations it is therefore sufficiently accurate to take 61 liters per cent. as the theoretical yield of 1 kilogr. (2.2 lbs.) of grape sugar.

From this the theoretical yield of other raw materials may be deduced. 95 parts of cane sugar yield 100 parts of fermentable sugar; the theoretical yield from 1 kilogr. (2.2 lbs.) of cane sugar is therefore 64.3 liter per cent. 9 kilogr. (19.8 lbs.) of starch, if completely converted into sugar, would yield 10 kilogr. (22 lbs.) of sugar, the theoretical yield from 1 kilogr. (2.2 lbs.) of starch would therefore be 67.9 liter per cent.

For saccharine substances, the figures are based upon complete fermentation, and for starchy materials, upon complete fermentation and conversion into sugar; by comparison it will be easy to find the degree of approximation attained by the practical yield.

The presence of lactic acid, which is frequently perceived, is according to Pasteur merely acci-

dental, and due to another ferment which, with the aid of the microscope, can be readily distinguished from yeast. If the yeast contains a portion of this ferment, lactic acid fermentation is induced besides alcoholic fermentation, and lactic acid, which is formed at the expense of sugar and consequently decreases the yield of alcohol, will be found among the above-mentioned products.

Examination and Preservation of Yeast.—The best yeast formerly attainable was brewer's yeast thrown off the beer during its fermentation. It is a semi-liquid pasty mass which can be used either in this state, or after compression. In the latter state it is known as compressed yeast, and forms a quite solid, homogeneous substance of a grayish-yellow color and a peculiar aromatic odor. Stored in a dry and cool place and excluded from the air as much as possible, it can be kept for a considerable time without losing any of its good qualities.

Yeast is also obtained by fermenting grain mashes in such a manner as to obtain as much yeast as possible. This process is conducted on a large scale in special factories, the product being a yeast which differs from brewer's yeast in not having an odor of hops.

Generally speaking, good yeast is recognized by its odor, which should be slightly acid and recall to mind that of whiskey or beer; it should show no trace of that of butyric acid, nor resemble that of sour milk, cheese, or that of any putrid or

ammoniacal substance. Compressed yeast can only be examined after preparing a paste with water. But it is always difficult to be sure of the good quality of yeast except by a fermenting experiment, which is conducted in the following manner:—

Divide carefully, 20 grammes (0.705 oz.) of the compressed yeast to be tested, in 2 liters (4.22 pints) of a 9 to 10 per cent. sugar solution, previously heated to 25° C. (77° F.). The solution is obtained by dissolving about 200 grammes (7.05 ozs.) of pure sugar in 2 liters (4.22 pints) of water, adding 2 grammes (30.86 grains) of sulphuric acid, heating to the boiling point for a few minutes, and allowing to cool to the required temperature. If the yeast is good, decomposition commences in 20 minutes at the utmost, which is indicated by the formation of a light froth upon the surface and the development of gas in the liquid. In a short time the odor of spirit makes its appearance, and the development of gas becomes stronger. The longer the time before the commencement of fermentation the poorer the yeast.

The active yeast remains divided in the fluid, while the dead yeast and other foreign substances settle to the bottom so that an estimate of their quantity can be readily formed. In making the experiment special attention must be paid to the odor in order to distinguish the alcoholic odor peculiar to sound ferment from the sharp and

pungent one of spoiled yeast. Every variety of yeast presenting the latter odor should be rejected even if fermentation is induced in the desired manner.

For completeness sake we give La Cambre's direction, which is based upon the same principle.

Take the same proportions of yeast (compressed or artificial) and wash as to be used in the distillery. Stir the yeast with some lukewarm water, mix it with the mash, and expose the mixture, which should show 10 to 12 per cent. gravity, to fermentation at a temperature of 34° to 36° C. (93.2° to 96.8° F.). If the ferment is of good quality, fermentation, which is recognized by a white circle of froth on the edge of the liquid, will make its appearance in about a quarter of an hour.

Adulterations of yeast by means of solid substances in order to increase its weight are readily recognized with the aid of the microscope; but an addition of a certain quantity of starch must not be considered an adulteration, as it is done the better to preserve the yeast.

Yeast, by storing in a room having a temperature not higher than 8° to 10° C. (46.4° to 50° F.), can be kept in summer for a week, and in winter for a month; it suffers less change the more compressed it is, which is facilitated by an addition of flour or starch.

Jeverson and Boldt of Copenhagen have patented the following method of preserving yeast: The raw

yeast is first carefully washed with water and the water removed by pressing and a centrifugal. But as this treatment does not render the yeast perfectly dry, it is placed in an apparatus in which a vacuum, or at least a very rarefied space can be produced. In this space the remnant of water is evaporated at a gentle heat, while the vapor is at the same time absorbed by hygrometric substances such as calcium chloride, etc. The yeast is finally exposed to a current of air, either ordinary or previously dried, or of carbonic acid according to the prevailing temperature or other circumstances. By this treatment, which is somewhat tedious and rather expensive, the yeast is finally obtained in the form of a very dry powder, which it is claimed will keep for several months, when put up in hermetically sealed boxes. For use the powder is converted to a thin paste with water of 20° to 30° C. (68° to 86° F.)

Savalle has patented a method for preserving yeast which consists in placing the yeast in a mixture of 85 to 65 parts of water and 15 to 35 parts of alcohol.

The quantity of yeast to be used for bringing a given quantity of mash into fermentation, depends on the condition of the mash, the purity of the yeast, and the quickness of time in which fermentation is to be induced. In Germany an average of 8 to 10 liters (2.11 to 2.64 gallons) of ordinary brewer's yeast, or 1 to 2 kilogr. (2.2 to 4.4

lbs.) of compressed yeast, are calculated for 1000 liters (264.11 gallons) of concentrated mash from potatoes or grain. For a larger quantity a proportionately smaller amount of yeast is required, thus for 2000 litres (528.25 gallons) 12 to 15 liters (3.17 to 3.96 gallons) of brewer's yeast, and so on. In England, distillers now generally use from 1 to $1\frac{1}{2}$ per cent. of fresh yeast, very rarely 2 per cent. Of this about three-fourths per cent. is added when the wort is let into the fermenting vat, and the remainder after the second day.

V.

PREPARATION OF VINOUS MASHES.

Preparation of Vinous Mashes from Saccharirerous Raw Materials.

The manufacture of alcohol from sugar and sacchariferous substances is in so far simpler than that from starch and amylaceous materials, that the process of forming sugar (mashing or boiling with acid) is omitted; the materials being converted into a suitable fluid or mass which, after the addition of a ferment, is allowed thoroughly to ferment.

1. *Raw Sugar.*

The simplest manner of working raw sugar is to dissolve it in hot water, and, after diluting the solution, to bring it into fermentation by means of a ferment. The process of fermentation being, however, very slow, it is much accelerated by an addition of sulphuric acid. To 100 kilogr. (220 lbs.) of sugar dissolved in hot water, add 0.5 to 1 kilogr. (1.1 to 2.2 lbs.) of sulphuric acid, previously diluted, and bring the mass into fermentation after diluting as much as necessary with cold water. The quantity of yeast added depends of course entirely on the desired duration of the fermenting process. Belgian distillers use for a fermenting process of 24 hours' duration, a solution showing 13 to 15 per cent. by the saccharometer (7° to 8° B.), add $2\frac{1}{2}$ to 8 per cent. of the weight of sugar of compressed yeast, and bring the mass into fermentation at 30° to 31° C. (86° to 87.8° F.). By using a 16 to 18 per cent. solution, and bringing into fermentation at 25° to 26° C. (77° to 78.8° F.), fermentation will run its course in about 48 hours. By adding a mash consisting of 2 to 3 per cent. of crushed rye and barley, the addition of yeast can be decreased. In England the yield from 101.2 lbs. of sugar is 10 gallons of proof spirit, the yield varying of course according to the quality of the sugar. West Indian sugar gives a very fine product, while that from beet sugar has a disagree-

able smell, which can only be removed by very considerable rectification.

2. *Glucose and Grape Sugar.*

The manufacture of alcohol from glucose and grape sugar can only be advantageously carried on under exceptionally occurring conditions. The process is the same as for raw sugar and molasses; a suitably concentrated solution is prepared, and, after acidulating with sulphuric acid, brought into fermentation at a suitable temperature.

La Cambre's process, as used in *France*, is as follows: Dissolve the grape sugar in hot water, acidulate the solution with 3.5 to 5.5 kilogr. (7.7 to 12.1 lbs.) of sulphuric acid, previously diluted, to 1000 kilogr. (2200 lbs.) of grape sugar and reduce the solution to $7\frac{1}{2}$ to 8° B. and a temperature of 25° C. (77° F.) by adding water. To bring the mixture into fermentation add 20 to 30 kilogr. (44 to 66 lbs.) of yeast previously mixed with 300 liters (79.24 gallons) of a mash consisting of 100 kilogr. (220 lbs.) of rye malt and barley malt, and cooled to 35° C. (95° F.). The highest yield obtained by the above process was from 15 or 16 gallons of alcohol from 100 kilogr. (220 lbs.) of grape sugar, which leads us to the conclusion that the grape sugar used contained a large percentage of non-fermentable substances, since grape sugar, with 90 per cent. of dry, pure sugar, should yield at least one-third more. Should it be necessary to accele-

rate the fermentation of the starch-sugar solutions, add, besides yeast, lees or feculencies of former distillations and more yeast, and bring the mass into fermentation at a higher temperature. The yield from glucose varies very much according to the quality of the material. 100 kilogr. (220 lbs.) of glucose very rich in sugar yielded from 11 to 12 gallons of alcohol, but on an average only 9 to 10 gallons were obtained.

3. *West Indian Molasses.*

Molasses is the name given to the syrup which remains after the crystallization of sugar; it is, in fact, the mother liquor of sugar. It is generally worked in the same manner as raw sugar. The use of sulphuric acid or lees, while always proper, is absolutely necessary with alkaline molasses. Dissolve the molasses in warm, clarified lees and dilute, or dissolve the molasses in warm water, add dilute sulphuric acid until litmus paper is reddened, and after pouring in a small excess of acid, dilute with water. By giving the acidulated fluid a concentration of 14 to 16 per cent. (8° to 9° B.) and bringing it into fermentation at about 26° C. (78.8° F.) with 2 per cent. of the molasses of good yeast, attenuation to 2.5 to 2 per cent. will be attained in 48 hours. A higher temperature than the above is required for a more rapid fermentation. The yield from 100 kilogr. (220 lbs.) of molasses is, according to La Cambre, as much as 14 gallons of alcohol.

By using 3 to 5 hectoliters (79.2 to 132 gallons) of clarified lees and 12 kilogr. (26.4 lbs.) of good yeast to a vat of 25 hectoliters (660 gallons) capacity, Merkel obtained in Belgium, 15 gallons of alcohol from 100 kilogr. (220 lbs.) of molasses.

In the West Indies the best rum is made solely from molasses. An inferior quality is made from the debris of the sugar cane; it has always a sharp, disagreeable, acid flavor, and frequently acquires an empyreuma, on which account it is given to the negroes who work in the sugar-houses, and is consequently called *negro-rum*.

In the fermented liquor from which the rum is distilled, acetic acid exists sometimes in large quantities, accompanying the ardent spirit without forming ether; but in distillation a certain quantity of acetic ether is formed, which, from its extreme volatility, rises in the first process of distillation, giving to the vapor a most disagreeable taste and smell; hence the colonial saying that the rum becomes *too hot* if rectified like European spirits. The cause of this is easily explained: the rectified spirit only forms a part of the distillate and contains, nevertheless, *all* the acetic ether.

Skilful distillers, who pride themselves on making these strong spirits most agreeable to the taste, take great care to remove all kinds of vegetable matter or refuse incapable of producing vinous fermentation, as such substances have a tendency to putrefy and the putrescent matter retards the

action, and gives a savor which is communicated to the distilled spirit.

The process in the West Indies is as follows:—

During the boiling of the sugar juice, the scum is removed from the surface and brought, together with a part of the juice, into a vat of 300 to 800 gallons capacity and mixed with molasses and water in the proportion of 25 gallons to 100. After blending the mixture thoroughly together, it is allowed to ferment for 3 or 4 days, or longer should there be a want of yeast or ferment to make it work, which often occurs at the commencement of the distilling season. When reduced to a due degree of acidity, which is ascertained by the subsidence of the fermentation, it is run into a still proportioned to the fermenting vat, and wrought off as low wines, in which state it is put into the still again. The first run, or discharge, after it is thus returned to the still is taken off as *high-wines*, as they are termed, in the proportion of 25 gallons to 300, the strength of which, when tried by the areometer, is from 28° to 32°. The second run has a strength of 23° to 26°, and is inferior in quality to the first, but is improved by mixing with a part of the first run which is of too ardent a nature to be used by itself.

In the Windward Islands one part of the skimmings is mixed with one part of water and one part of the lees of former distillations. In twenty-four hours the mixture begins to ferment, when to every

100 gallons of the fermenting liquor 6 gallons of molasses are added, the same operation being repeated a day or two afterwards. The fermentation is regulated by the addition of cold or warm water. The lees or feculencies remaining in the still, and which are called *dunder*, serve all the purposes of yeast in the fermentation. The attenuating properties of this ferment are such that the materials with which it is mixed yield a much greater proportion of spirit than could be obtained if they were fermented without it. It is consequently carefully collected, and, when the distilling season is over, preserved in such quantities as will fill almost all of the fermenting vats. It soon becomes covered with so thick a film as to exclude the air, and the sediment leaves the intermediate fluid pure and of a bright amber color, which, when carefully drawn off, is employed as already described in proportions suited to the nature of the fermentation. Dunder has a somewhat bitter taste; it is claimed that it increases considerably the aroma of the rum. Besides this substance, different other substances, such as tartar, saltpetre, sea-water or common salt, are frequently added during fermentation.

In the beginning of the distilling season more sugar-juice is employed than is afterwards found requisite; the reason of this is that the dunder, after being kept for a long period, has lost a part of its effect, and the scum or froth from the sugar of the first boiling of the season is not so rich as that in

the months of March, April, and May, which is the most favorable time. The following proportions are usually employed at starting: For every 136 gallons content of the vat, pour in 61 gallons of skimmings, 7 gallons of molasses, and 68 gallons of water. When the dunder is good, equal quantities of skimmings, water, and dunder are used, and for every 100 gallons of this mixture, 10 of molasses are added. Should the sugar-mill not be in operation, and skimmings not be obtainable, it is found advantageous to employ equal parts of dunder and water, and to mix with every 136 gallons of the compound 27 gallons of molasses. The yield of rum varies between 10 and 15 per cent. of the mixture, but depends very much on the qualities of the raw materials, the weather, and the season; hence the manufacturer regulates the composition of the fluid according to the qualities of the constituents and external circumstances.

The richness of flavor peculiar to Jamaica rum has rendered it famous in all parts of the world. The flavor is undoubtedly derived from the raw juice and the fragments of the sugar cane, which are added to the fermenting liquor. The essential oil of the cane is thus imparted to the fluid and carried over in the distillation. Rum is much improved by age; many planters age it factitiously by the addition of pine-apple juice.

4. *Beet Sugar Molasses.*

Many difficulties were encountered in the first attempts in employing beet-sugar molasses in the manufacture of spirit, as it was almost impossible to secure a regular course of fermentation with any degree of certainty. The reason for this was found in the strongly alkaline nature of the molasses. Satisfactory results were obtained by employing acids for the removal of the alkaline reaction.

The raw spirit obtained from beet sugar molasses possesses a very disagreeable taste and odor. Experience has shown that conversion into very high-graded spirit (94 to 96 per cent. Tr.) suffices to remove the odor and taste so that the derivation of the spirit can scarcely be recognized.

The process of working beet sugar molasses is essentially the same as for West Indian molasses. Dissolve the molasses in hot water, acidulate the solution with sulphuric acid, and, after diluting, bring it into fermentation. The water employed for dissolving the molasses should, of course, be sufficiently hot to insure the required fermenting temperature for the diluted solution. The quantity of sulphuric acid depends on the alkaline condition of the molasses; a test with litmus paper is the best guide. Add, with constant stirring, dilute the acid, until the paper is slightly reddened. On an average, 1.5 per cent of the molasses of concen-

trated acid will have to be employed. In using, as is sometimes the case, clarified lees, less sulphuric acid is taken. The degree of dilution of the molasses, the quantity and kind of ferment, the temperature at which the mass is brought into fermentation, depend chiefly on the revenue laws. The concentration is generally 14 to 24 per cent. by the saccharometer.

The process in the largest molasses distillery in France is as follows:—* 3700 kilogr. (8140 lbs.) of molasses are taken for each fermenting vat of 1700 hectoliters (41,884 gallons) capacity, which gives to the mash a concentration of about 14 per cent. To this is added sufficient molasses lees, which increases the concentration about 5 per cent. The mass is brought to fermentation with beer yeast at a temperature of from 20° to 25° C. (68° to 77° F.). Fermentation is extremely violent, and produces in the extraordinarily large quantity of mash fermenting in one vat, such an increase of temperature as to necessitate the cooling of the fermenting mass by cold water, circulating in large serpentine pipes placed in the centre of the vat. The temperature must never rise above 34° C. (93.2° F.). Should the commencement of fermentation be delayed, the temperature can be

* The product is taxed, but the tax is only collected when the product passes into consumption; otherwise it is exempt from duty.

raised by the circulation of warm water through the serpentine pipes.

Fermentation is generally considered complete in 48 hours. In the distillery mentioned five of the above enormous vats are handled in two days.

The product of one day is given as 280 hectoliters (7392 gallons) of alcohol of 97 per cent. Supposing the conditions remain the same every day, this product would correspond to a yield of 13.6 gallons from 100 kilograms (220 lbs.) of molasses.

By evaporating, etc., the lees, potash is gained as a by-product.

In a distillery in Würtemburg* acidulated unboiled molasses of 19 to 20 per cent. concentration is brought into fermentation at 24° C. (75.2° F.) and allowed to attenuate to 7 per cent. Five per cent. of the weight of molasses of green malt is used. The yield is 10.5 to 11 gallons from 100 kilogr. (220 lbs.) of molasses.

In a Bohemian distillery† 8 lbs. of green malt, with an addition of 0.25 lb. of compressed yeast and 3 liters (6.33 pints) of beer yeast, are used for each cwt. of molasses.

* Taxation: Malt tax only, at the rate of 2 florins, 5 kreutzer (about 86 c.) per cwt. of dry malt and 1 fl. 10 krtz. (about 48 c.) per cwt. of green malt.

† Tax is levied according to the capacity of the fermenting vats without limit as to their use; hence it is desirable to complete fermentation as soon as possible.

In a Belgian distillery* the following process is observed:—

Molasses of 40° concentration is brought into iron fermenting vats, and, after diluting to about 37° B., mashed with about 0.3 liter (0.63 pint) of sulphuric acid to each 100 kilogr. (220 lbs.) of molasses. The mass is then diluted to 8° or 9° B. by adding warm or cold water, as may be required, so as to insure a temperature of 28° to 30° C. (82.4 to 86° F.), constant and careful stirring being absolutely necessary during the diluting process. The fermenting vats should be about half full. 4 to 5 per cent. of the weight of the molasses of yeast is then added and thoroughly mixed with the mass. Fermentation begins in a quarter of an hour, and becomes so vigorous in 5 hours as to reduce the concentration of the mash to 5° or 6° B. The mash is then brought to 10° to 11° B. by the addition of molasses of 25° B. When by continued fermentation the concentration of the mash is again reduced to 5° or 6° B., another addition of molasses of 25° B. is made, and this operation is repeated from time to time, until after 7 hours from the time of first charging the vat, the latter is completely filled. We would remark that the concentration of the mash should at no time exceed 10° to 12° B.

* Tax is levied according to the capacity of the fermenting vats at the rate of 7 francs (about $1.40) per hectoliter (22.0096 imperial gallons), but the vats have to be emptied every 24 hours.

The temperature during the entire process is kept at 28° to 30° C. (82.4° to 86° F.), this being considered an essential condition for success, and is effected in most distilleries by the circulation of water or steam through serpentine pipes.

A strong formation of froth in the commencement of fermentation is counteracted by the use of oil or of fat.

The entire process, including distillation, must be finished in 24 hours, and depends exclusively on the quality of the yeast. The mash attenuates to 3 to 3.5° (5.3 to 6 per cent.), which is considered a good limit.

The yield is about 10.5 gallons from 100 kilogr. (220 lbs.) of molasses. Considering that no malt is added, the yield is a large one, which no doubt is due to the fact that the large quantity of vigorous yeast acts, in consequence of the gradual addition of molasses, always upon a proportionally small quantity of the material.

In German distilleries compressed beer yeast has been lately substituted for artificial yeast. In such case only half the usual quantity of kiln-dried malt is used, the other half being replaced by one-half its weight of compressed beer yeast, *i. e.* in place of 4 parts of kiln-dried malt, 2 parts of kiln-dried malt and 1 part of compressed yeast are used. On account of its lower price, the use of beer yeast is advantageous, but it must be of excellent quality,

as otherwise fermentation will not proceed regularly.

By the results obtained from molasses mashes worked under the various revenue systems, we draw the general conclusion that the yield of alcohol from the raw material is but little affected by the mode of taxation, in as far as it requires more concentrated mash and slow fermentation, or more diluted mash and quick fermentation. In the first case a part of the sugar remains unfermented by reason of the foreign substances present and the increase in the percentage of alcohol impeding fermentation; the same happening in the latter case, as it is found advantageous to cut short fermentation instead of allowing it to proceed to the attainable limit. In both cases too much fermenting material is used: in the first because strongly concentrated mashes are difficult to bring into fermentation, and in the latter because the course of fermentation can only be accelerated by such means in connection with heat.

5. *Sugar Beets.*

Sugar beets are a very valuable material for the manufacture of spirit wherever the revenue system is such as not to impede their proper manner of treatment. Like potatoes, they give an extraordinarily large yield per acre, and, when used for the manufacture of spirit, furnish a valuable fodder. In Belgium and Germany, distilleries are frequently

to be found attached to the beet-root sugar manufactories; and the combination of the industries possesses the advantage that, in a season when the proportion of sugar in the roots is too poor to yield much profit to the manufacturer as sugar, he may ferment the sugar-containing juice and obtain a fair yield of spirit. Beets, to be available to the distiller, may contain only 5 to 6 per cent. of sugar, but for the manufacture of sugar they must contain at least 8 to 10 per cent. Indeed it is maintained by the advocates of beet-root distilleries, that the distillation of spirit is a more profitable business than the manufacture of beet-root sugar.

Although it would appear to be a simple matter to extract the juice from the previously pulped root, this is, notwithstanding the large quantity of juice, viz., 96 per cent. of the weight, a difficult matter, because the remaining 4 per cent. of substance has all the properties of a sponge and tenaciously retains the juice; it is this spongy nature of the solid constituents of the root which prevents the conversion of the whole root into a sufficiently concentrated mash. If it were possible to set up fermentation in the thick pulp obtained from the roots, 100 lbs. of it, taking the amount of sugar at 11 per cent., would yield 3.5 liters (7.39 pints) of alcohol, a quantity sufficiently large to be remunerative, even with a very low market price of spirits.

We give in the following a process of extracting

the juice, which has been introduced in Germany by Siemens, and with some modification in France by Champonnois.

The beets are cut in slices by a suitable machine, and the juice is obtained by macerating the slices, according to Siemens, with water, and, according to Champonnois, with spent wash from former distillations.

The possibility of obtaining the juice from the sliced roots by maceration is based upon the fact that when the slices are placed in water the juice does not remain unaltered in the cells, but is mixed through the cell walls, in consequence of what is called endosmose and exosmose, with the water, so that a sugar solution with a medium percentage of sugar is formed in the cells, as well as outside of them. In the same manner as in water, the slices act also in a sugar solution, whose percentage of sugar is less than that of the juice of the beets; an equalization of the percentage of sugar takes place.

An example will completely illustrate this. To make the matter comprehensible we will assume that 100 lbs. of beets are equal to 100 lbs. of juice, though actually they contain only, as previously stated, 96 lbs.

By pouring upon 100 lbs. of sliced beets, whose juice contains 12 per cent. of sugar, 100 lbs. of water, and allowing the water to stand for some time over the slices, it is converted into a sugar

solution containing 6 per cent. of sugar, and the percentage of sugar in the juice in the slices is also reduced to 6 per cent., viz: $\frac{12 + 0}{2} = 6$.

By drawing off the 100 lbs. of 6 per cent. sugar solution, and pouring them upon 100 lbs. of fresh slices of beets, a 9 per cent. sacchariferous fluid is obtained after some time, because $\frac{6 + 12}{2} = 9$.

By drawing off the 9 per cent. fluid, and pouring it upon 100 lbs. of fresh beet slices, the result will be a sacchariferous fluid of 10.5 per cent., because $\frac{9 + 12}{2} = 10.5$.

By again pouring the 100 lbs. of 10.5 per cent. fluid over 100 lbs. of fresh slices, 100 lbs. of sugar solution of 11.25 per cent. are obtained.

This latter percentage of sugar approaches very nearly that of the beet juice, but could be increased to 11.6 per cent. by pouring the fluid once more upon fresh slices. Hence by maceration 11.25 per cent. of the 12 per cent. of sugar contained in the beets has been transferred to the maceration-juice; far more than could be obtained by pressure.

Let us return now to the beet-slices, whose percentage of sugar has been reduced to 6 per cent. by maceration with pure water. By pouring over them 100 lbs. of fresh water, the amount of sugar is of course reduced to 3 per cent. By drawing off the 3 per cent. sugar solution, and again pouring

100 lbs. of water over the slices, the amount of sugar in them is reduced to 1.5 per cent., and by again drawing off the 1.5 per cent. fluid and pouring over 100 lbs. of water, the slices are exhausted to 0.7 per cent. of sugar.

It is self-evident that the maceration has to be carried on systematically. The most concentrated sugar-juice is poured upon fresh beet slices, the less concentrated upon slices partly freed from sugar, and water upon nearly exhausted slices. Juice sufficiently concentrated is set in fermentation, and the exhausted slices are either used at once for fodder or preserved in pits.

Experience has shown that complete maceration takes place only at 80° to 85° C. (176° to 185° F.), so that the slices must be dried at least at this temperature in order to completely yield their juice to colder fluids In the cold, maceration is incomplete, and at a higher temperature the slices become too soft, which renders lixiviation more difficult. We will remark here that with hot maceration the weight of the slice does not remain unaltered, as has been assumed above in illustrating the macerating process in order to simplify the example. The slices shrivel up, and do not keep back as much juice as in a fresh state; hence a larger volume of sacchariferous fluid is obtained than that of the water poured upon the slices.

An addition of sulphuric acid to the macerating fluid is, according to Siemens, of advantage. The

proportion used is about 1 lb. acid to 1000 lbs. of beets.

Maceration can be effected by different methods. The macerating fluid is either poured upon the beet slices, or the latter, contained in nets, are submerged in the fluid (Siemens' process), or the macerating fluid is allowed to pass slowly through a series of vessels containing the beet slices. The last method is the one formerly used in sugar manufactories.

In considering the first method, let us assume that 45 to 50 cwt. of beets yielding 2300 to 2500 liters (607.49 to 660.31 gallons) of juice are to be worked daily.

The macerating vessels used have each a capacity of 630 liters (166.40 gallons). Besides the actual bottom they are provided with a perforated false one of sheet-copper upon which the slices rest. Each vat is connected with the succeeding one by a pipe leaving the first vat on one side below the false bottom, then rising up and entering the succeeding vat through the side near the top. The pipe is provided with a cock. To be able to connect the last vat with the first without the use of a long pipe system, the vats are arranged in a circle or a square. A pipe with joints over each vat for the admission of water runs over the entire series. The fluid in the vats is heated by a steam-pipe under the false bottom, or, still better, but more expensive, by a steam serpentine pipe placed below

the false bottom. The fluid in the vat is drawn off through a discharge-cock below the actual bottom.

Maceration is of course effected the more completely, the larger the number of macerating vats used, but for illustrating the method, we will take only four, *A*, *B*, *C*, *D*, the smallest number admissible. The work is proceeded with as follows: Five cwt. of sliced beets are placed in vat *A*, and after pouring 100 to 200 grammes (3.5 to 7.05 ozs.) of dilute sulphuric acid over them, 200 liters (52.82 gallons) of hot water are admitted from the reservoir. The slices are kept under the fluid by placing a perforated disk upon them. The temperature as mentioned before must be 85° C. (185° F.), at which the slices soon wither and shrivel.

In about three-quarters of an hour, during which vat *B* has been charged with an equal weight of slices, which have also been sprinkled with dilute sulphuric acid, the cock of the pipe connecting *A* with *B* is opened and hot water slowly admitted to *A*, by which the sugar solution formed in *A* is forced into *B*. As soon as the required quantity of fluid has been transferred to *B*, the flow of water into *A* is stopped. The temperature in *B* must be raised to 85° C. (185° F.)

In three-quarters of an hour, during which *C* has been charged with beet slices sprinkled with dilute sulphuric acid, the vat *B* is connected with

C and water admitted to *A*. The sugar solution in *A* is forced into *B*, and that in *B* into *C*. When *C* is sufficiently filled, the flow of water into *A* is stopped, and the contents of *C* are heated to 85° C. (185° F.)

In three quarters of an hour, during which the last vat *D* has been charged with beet slices, and dilute sulphuric acid poured upon them, the vat *C* is connected with *D* and the fluid forced from *A* into *B*, from *B* into *C*, and from *C* into *D*, by admitting hot water into *A*. The temperature in *D* is raised to 85° C. (185° F.)

In three-quarters of an hour the cock admitting water into *A*, and the discharge cock in the bottom of *D*, are opened at the same time, and closed again as soon as about 200 liters (52.82 gallons) of the sacchariferous fluid, which is now sufficiently concentrated, have been discharged from *D*. This fluid is now ready for fermentation after cooling.

The fluid in *A*, which is now very poor in sugar, is also drawn off and conducted to the water reservoir, and the vat, after being emptied of the exhausted slices, is immediately refilled with the necessary quantity of fresh material, over which is poured the above-mentioned quantity of sulphuric acid.

B becomes now vat No. 1, and *A* the last. *D* is connected with *A*, water admitted into *B*, and the sacchariferous fluid forced from *B* into *C*, from *C* into *D*, and from *D* into *A*, which contains the

fresh slices. The temperature in *A* is of course raised to 85° C. (185° F.)

Thus the work is continued, *C* becoming vat No. 1, after drawing off the sacchariferous fluid from *A*, and so on.

Champonnois uses, instead of water, hot spent wash from former distillations. The object of this is partly to save the expense of heating the water, partly to make the lixiviated slices richer in nitrogen and consequently more nourishing, and partly to avoid the removal of the wash, which is sometimes troublesome. A distillery working according to Champonnois' system requires scarcely any water, and no wash is allowed to run off. The wash drawn off from the still is either immediately used, while boiling hot, for maceration, or is conducted into a reservoir which is heated by the waste heat of the chimney of the second still.

The apparatus and progress of maceration are the same as described with water. An essential difference between the two methods is, that Champonnois does not heat the fluid in the macerating vats, but allows the boiling hot wash to enter the first vat, and to cool off to the required degree by passing through the successive vats. According to all experience, complete maceration is impossible under these circumstances, and increasing the time of maceration to one hour, as proposed by Champonnois, will not rectify the evil.

We turn now to Siemens' process, which is based

upon the method of maceration formerly introduced into beet sugar manufactories by Dombasle. The beet slices are submerged in the macerating fluid instead of the latter flowing over them.

Suppose 1800 kilogr. (3960 lbs.) of beets, which will yield about 1800 liters (475.42 gallons) of juice, are to be worked in 14 hours. The sliced roots must be withered before maceration. This is effected by means of two flat pans heated by direct fire, or in two flat, round vats provided with a serpentine steam pipe. The pans or vats should have a capacity of 300 liters (79.24 gallons) of water and 400 lbs. of beet slices.

The macerating vessels, of which there are six, have each a capacity of 100 liters (26.41 gallons) of water and 200 lbs. of wilted beet slices. The vats are arranged in a circle, in the centre of which stands a revolving crane for bringing the nets with the slices from one vessel into the other. The nets are made of thin cord, and are fastened above to a copper ring by which they are held open the entire width of the vessel, so that the slices can be conveniently stirred about.

In the commencement of the work 300 liters (79.24 gallons) of water are placed in the vessel used for wilting the slices. When the water is heated to about 90° C. (194° F.), 6.5 ozs. of sulphuric acid, previously diluted, are added. A net is now introduced and charged as quickly as possible with 400 lbs. of sliced beets. By diligent pressing

down of the slices, which at first project above the fluid, the temperature is lowered to 85° C. (185° F.) at which it is kept during the rest of the operation. The slices soon shrivel up and are entirely covered by the fluid. They are sufficiently wilted when they have lost their elasticity, it being necessary to observe this point carefully, since slices wilted either too much or too little cannot be completely exhausted by maceration.

The wilted slices, in portions of 200 lbs., are then placed in nets and brought into the macerating vessels, each of which contains 100 liters (26.41 gallons) of water. All portions are successively submerged in the separate vessels. As the first slices are placed in water and less sacchariferous fluid, and consequently lose sugar quicker than the succeeding slices, six vessels suffice to completely exhaust even the last portions. In order to effect a quick and complete maceration, the slices must be diligently stirred, and in bringing the nets, by means of the crane, from one vessel into the other, the liquid must be allowed to drain off uniformly, so that an equal quantity of fluid is retained in all vessels, and as little of the more concentrated fluid as possible is carried over into the succeeding, more diluted fluid.

After adding 6.5 ozs. of sulphuric acid to the fluid in the wilting vessel, 400 lbs. of fresh slices are immediately placed in it. The temperature is raised to 85° C. (185° F.) etc. etc. After wilting

four portions of slices the fluid is sufficiently saccharíferous to be drawn off, but, before this is done, it must be heated to the boiling point, and should it not be sufficiently clear, entire clarification is effected by a further addition of sulphuric acid. After cooling, the fluid is brought into the fermenting vat. The concentration of the fluid is increased by cooling with a fan, and contact with air has also a favorable influence upon the course of fermentation.

After removal of the saccharíferous fluid the wilting vessel is refilled with the saccharíferous fluid from the macerating vessels, and fresh slices wilted in it, two operations making it sufficiently concentrated to be drawn off. The liquid is then clarified by heating to the boiling point, etc.

The clarified saccharíferous fluid is cooled to 25° to 23° C. (77° to 73.4° F.) and then brought into the fermenting vats. The first portion is brought into fermentation by the addition of an equal volume of fermenting fluid of the preceding day, which Siemens found the most suitable ferment. Some yeast is added from time to time. The second portion of saccharíferous fluid is brought into the vat from which the fermenting fluid for the first portion has been taken. The succeeding instalments of saccharíferous fluid are added to the first portion, which in the meanwhile has commenced to ferment. The fermenting vat being thus gradually filled, fermentation goes on steadily and is complete after

twice 24 hours on the third day. The external phenomena are those of a vigorous fermentation; no tenacious scum is formed, and over-fermentation need not be feared.

La Cambre combines the two macerating processes just described, and recommends an apparatus which, he says, can be made by any carpenter. It consists of a trough with four sides, 4 to 6 meters (13.12 to 19.68 feet) long, 0.6 to 0.8 meter (1.97 to 2.62 feet) wide, and 0.7 to 0.8 meter (2.29 to 2.62 feet) deep. It is divided lengthwise into six to eight divisions, which are connected by small partitions in such a manner that the fluid placed in the first division is forced to run through the other divisions from above to below.* The slices are immersed in suitable square wicker baskets, which are very cheap, or, better, in baskets of sheet-copper or sheet-brass, or copper or brass wire.

To illustrate the process of maceration as briefly as possible, we will assume the macerating trough to have only four divisions, numbered 1, 2, 3, 4.

All divisions are filled half full with boiling water.

A basket, *A*, is first immersed in division 4.

In ten minutes it is brought into division 3,

* The fluid passes from the first division through a small opening near the bottom of the dividing wall into the partition of the second division, rises up and pours over the edge into the second division, and from this in the same manner into the third, and so on.

while a basket, *B*, with fresh slices is brought into division 4.

In ten minutes the basket *A* is brought into 2, *B* into 3, and a third basket, *C*, with fresh slices, into 4, while boiling water is admitted into 1, which gradually circulates in the different divisions.

In ten minutes more *A* is brought into 1, *B* into 2, *C* into 3, and a basket with fresh slices into 4, while a certain quantity of boiling water is always admitted into 1.

The water, as will be seen, meets in its course slices always increasing in richness, and finally runs out below from division 4, while the slices in their course pass constantly into a fluid poorer in sugar. Complete exhaustion of the slices is accomplished with 8 or 9 divisions, and with thorough regulation of the admission of water and the discharge of juice, and heating the fluid in some divisions from time to time with direct steam.

The resulting juice has nearly the concentration of that in the beet, and it is not necessary to use more water than an equal of the weight of the beets. To prevent an injurious alteration of the juice, La Cambre adds some tan extract to the macerating water, though sulphuric acid will answer the same purpose. The resulting juice, which is very clear and pure, is cooled and brought into fermentation. It is claimed that by this hot method of maceration the slices lose 40 to 50 per cent. of weight; the residue is an excellent fodder.

We will yet mention Weil's method, patented a few years since in France and Belgium, and recently introduced into some parts of Germany.

The beets are cut in slices by a cutting machine, and the slices, as they come from the machine, are brought into a vat of water containing sulphuric acid, and heated to the boiling point by steam directly introduced. 8 to 12 liters (2.11 to 3.17 gallons) of water, and 1 to 1½ lbs. of concentrated acid are used for every 100 lbs. of beets. When the vat is charged with the required quantity of slices, it is tightly closed, and the boiling continued, with occasional stirring with a wooden paddle or a stirring apparatus.

In two to three hours the contents of the vat have been converted into a clear mash. The hot liquid is then neutralized with 1 lb. of whiting for every lb. of sulphuric acid used, which leaves it the required degree of acid reaction. The fluid is then separated by means of a centrifugal machine, pressing or filtering from the gypsum which has been formed, and the pulp. The residue is once more mixed with water, and again treated with a centrifugal machine, or pressed or filtered.

The resulting fluid is cooled to 30° or 25° C. (86° or 77° F.), and brought into fermentation by an addition of beer yeast or compressed yeast. The progress of fermentation is very regular, and is complete in 24 to 36 hours. A yield of 5½ liters (1.45 gallons) of spirit of 84 per cent. is claimed

from 100 lbs. of beets. The by-product of fodder is lost.

The object of this treatment of the beet is to prevent the absorption of a large quantity of the juice by a partial liquefaction of the pulp. The supposition that by the action of sulphuric acid upon the cellulose, sugar is formed is by no means justified. Besides the use of pressure, centrifugal force or filtration for obtaining juice is a great disadvantage, so that this method can scarcely be recommended.

Besides the above-described methods of obtaining the juice there are several others, but as none of them have been generally introduced it will be readily understood that a satisfactory process of working beets is still wanting.

6. *Grapes.*

The distillation of spirits from wine is chiefly carried on in France, Spain, Portugal, and in the United States in California. The yearly production of brandy in France alone amounts to over 450,000 hectoliters (11,880,000 gallons) of 85 per cent., and over 400,000 hectoliters (10,560,000 gallons) of 60 per cent. The quality of the spirit is indirectly affected by the degree of ripeness of the grapes, and directly by the care bestowed upon the fermentation and distillation, the more or less intimate mixture of the volatile principles of the wine with the alcohol, and the age of the wine. Old

wine yields a spirit of better quality than new wine. The spirit from white wines is of a much finer quality than that from red wines, the reason being that they contain more of the essential oil of the grapes. It is also a singular fact that those wines which carry with them a certain taste of the soil communicate it to the brandy derived from them by distillation; thus the wines of Selluel, in Dauphiné, give a brandy which has the flavor and taste of Florentine iris; those of St. Pierre, in Vivarais, give a spirit which smells of the violet, and so of many other varieties.

The better qualities of brandy are invariably distilled from white wines: first, because a greater yield of brandy, and of a better quality is obtained; and secondly, because those wines fine more quickly and can be distilled into brandy sooner than the red wines.

The principal Cognac district of France begins at Angoulême, about 300 miles south of Paris, and comprises from fifty to sixty square miles. The soil is principally clayey and flinty rock, supported by a bed of chalk or limestone, and occasionally of marl.

In the Deux-Charentes there are three kinds of vineyards called "*vignes pleines*," "*vignes en allées*," and "*vignes à lœufs*." In each the vines are planted in rows, which in the first are 5 feet apart. The *vignes en allées* consist of long, narrow strips of land planted with vines in rows, every fourth or fifth row or so having a slip of ground sown with

grain or vegetables in between. In these vineyards, the vines, as a rule, are planted rather wide apart. The *vignes à bœufs* are so termed from the rows being wide enough apart to admit of oxen and a plow passing between. The vines, as a rule, are left without support. The producers are mostly small farmers who cultivate their own vineyards, with little if any help.

The distillation of brandy is carried on either by the proprietors of the vineyards themselves, or by dealers who buy the wines to be distilled, and manufacture what is known as *trois-six* brandy. In order to explain this term we will state that brandy, as sold in France, is generally of two degrees of gravity, these strengths being designated as *à preuve de Holland* and *à preuve d'huile*, the former varying from 18° to 20° B. The stronger liquids are valued according to the quantity of *eau de vie*, or brandy *à preuve de Holland* that a given quantity will furnish on the addition of the proper proportion of water. These strengths are usually twelve, namely, *five-six*, *four-five*, *three-four*, *two-three*, *three-five*, *four-seven*, *five-nine*, *six-eleven*, *three-six*, *three-seven*, *three-eight*, and *three-nine*, but the last is rarely made. The meaning of these strengths is understood in the following sense: If a spirit be *trois-six* (three-six) three measures of the spirit will give a liquor *à preuve de Holland* when added to six measures of water, and so of the remainder.

The work of manufacturing brandy does not

require the same care as that of wines intended for beverages, though care must be exercised to produce as much alcohol of a pure taste as possible. The grapes are picked, for the most part, by women who use a hook-shaped knife to sever the stems. Each carries with her a small wooden box with sloping sides, into which the fruit is thrown. When these boxes become full they are emptied into baskets which are carried to the cart at the edge of the vineyard. The carts have long bodies, very high wheels, and a huge tub, fixed between four upright stakes. Within the tub is a lad, who treads upon the grapes to reduce their bulk, and in a measure press out their juice. The cart, when loaded, is drawn to the neighboring press-house. The grapes are next emptied, through an opening in the wall, upon a sloping stone floor, where they are crushed by an ordinary grape mill, which, however, forces out only a portion of their juice. Formerly the juice was trodden out by the feet of the laborers. It runs down the sloping floor into a covered trough at the lower end, by which it is led into a tank, whence it is emptied into casks, and then left to ferment.

A centrifugal machine has recently been employed by Reihlen for obtaining the juice from the grapes. The work is carried on very quickly, and a very pure juice is obtained, but the grapes must be very ripe.

As already said, the mill does not press all the

juice from the grapes, and so the "must" is shovelled through an opening in the wall into a large shallow trough, at the foot of the press. Then it is heaped up in the centre of the trough, into what is called the *motte*, a form like a millstone, and subjected to powerful pressure. The sides of the *motte* are now trimmed, the screw loosened, and the trimmings piled on the top, when the pressure is again applied. This process is repeated until the must has been subjected to four pressures. Each pressure lasts about two hours, except the last, which, being generally put on in the evening, continues all night. Next day the must is spread out in the trough, watered from a watering trough, and raked about in the water for an hour. The water being drawn off, the must is again put under pressure, and the juice obtained is mixed with the water, and the whole put into a cask to ferment.

The must or juice obtained from the milling and four previous pressures, is put in casks, vats, or cisterns, to ferment, and it is from this that the best quality of brandy is obtained.

The fermentation of the juice takes place at 12° to 18° C. (53.6° to 64.4° F.) and is solely produced by the deposit of ferment upon the surface of the berries which mixes with the juice. An addition of warm water accelerates commencement of fermentation, especially in a cool gathering season. Fermentation lasts frequently two to three months. Contact with air, especially of the solid parts of

the must, which on rising offer a large surface to the air, should be carefully avoided, as it is injurious to fermentation.

The fermented fluid, which is now called "wine," is at once subjected to distillation. Should the juice show a small percentage of sugar, glucose or molasses can be advantageously added immediately after the juice has been pressed out, and allowed to ferment with the must.

An inferior variety of brandy or *eau de vie de marcs* is obtained by distilling the lees deposited by wines when kept, the marcs or refuse of the grapes from the vine-press, the scrapings of wine casks, etc.

The marcs from the vine-press are prepared for distillation by breaking the cakes into pieces, and throwing them into water. A temperature of 21° to 26° C. (69.8° to 78.8° F.) is kept up, and in the course of a short time fermentation sets in; when this has ceased, the solution is drawn off and distilled.

The fermentation of the cakes is sometimes effected in large pits, where they are covered with earth. The progress of fermentation is known by thrusting the hand into the heap. When the temperature decreases, the fermentation is said to be finished. The contents are then taken out, water in proper quantity added, and distilled. By this process 100 lbs. of marcs are said to yield 1 lb. of brandy.

Ethyl pelargonate ($C_2H_5C_9H_{17}O_2$), the ether of pelargonic acid, is a liquid possessing a most powerful and intoxicating odor. The aroma of wine is in a great measure due to the formation of this ether during fermentation. When wines or marcs containing this ether are distilled, an oily liquid passes over towards the close of the operation, and consists in a great measure of crude ethyl pelargonate, and imparts the aromatic odor which cognac and other liquors possess. It is very advantageous to add some sulphuric acid, in the proportion of ½ lb. of acid and 1 to 1½ bucketfuls of water to 100 lbs. of the ethyl pelargonate. The product, which is clarified by rectification, and known as *cognac oil*, is much in demand for the manufacture of artificial cognac, and brings a high price.

In England artificial cognac is prepared in the following manner: Dilute the pure alcohol to the proof pitch, add to every 100 lbs. weight of it from half a pound to a pound of argol (crude winestone) dissolved in water, some bruised French plums, and a quart of good cognac. Distil this mixture over a gentle fire, in an alembic provided with an agitator. The addition of cognac and argol introduces ethyl pelargonate, and if a little acetic ether be added to the distillate, the liquor acquires the peculiar taste of genuine cognac; color with burnt sugar, if necessary, and add a little tannic acid to impart astringency.

VI.

FABRICATION OF ALCOHOL FROM AMYLACEOUS RAW MATERIALS.

I. Preparation of Vinous Mash from Grain.

The varieties of grain most frequently used are rye or wheat, or a mixture of both, with barley malt, and maize in countries where it yields an abundant crop. A mixture of rye or wheat malt with barley malt is occasionally used. Unmalted barley or oats are only employed under exceptional circumstances.

The proportion of malt to grain varies very much. Formerly one part of malt to two or three parts of unmalted grain was generally used, but experience has proved that the quantity can be reduced at least one-sixth to one-seventh.

In most distilleries kiln-dried malt is still preferred, but since it is proved that green malt has at least as energetic an effect in producing sugar as the same weight of dry malt, we would strongly urge the employment of green malt as being more economical. We would remind our readers that 100 lbs. of malt just taken from the kiln represent 125 lbs. of barley, and 100 lbs. of dry malt stored for some time 115 lbs. of barley, while 100 lbs. of green malt represent 67 lbs. of barley.

The preparation of the vinous mash includes the following operations:—

1. Grinding or bruising.
2. Mashing.
3. Cleansing the utensils.
4. Cooling the mash.
5. Fermenting the mash.

1. *Grinding or Bruising.*

The grain before grinding should be cleansed as much as possible, because the admixture of impurities not only decreases the quantity of useful raw material, but introduces into the mash foreign substances (for instance ferments), which exert an injurious effect upon the fermentation, and the purity of the product. When it is to be ground into meal, the grain is taken into a room immediately over the mill-chamber and discharged through the trap doors into cloth sleeves, which conduct it to the hoppers leading into the mill-room. The grain must be broken up, the smaller the harder it is, for instance maize and some varieties of wheat. The malt is passed through a crushing mill consisting of two rollers placed nearly in contact, which gives a loose, woolly product consisting of a mixture of the crushed flour body and the torn hulls.

The ground grain and crushed malt, especially the latter, should be used as soon as possible; they

can be kept for a short time only by storing them in a perfectly dry room in low piles.

2. *Mashing.*

The purpose of mashing is to convert as completely as possible the starch of the grain and malt into sugar by the diastase of the malt.

a. Preparation of thick mash.—The method of mashing differs in the various distilleries. Generally speaking, a preparatory doughing-in precedes the actual mashing process. In doughing-in the grist is thoroughly soaked with water, and then brought to the required mashing temperature by the addition of boiling water, or by the introduction of steam.

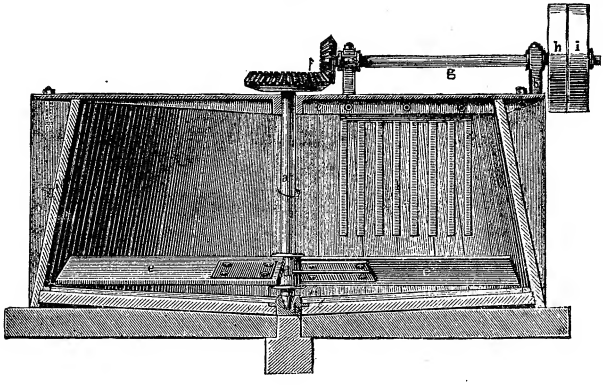
The mash vat is made of wood, or cast-iron plates firmly bolted together. If mashing is to be effected by manual labor, the vat should have an oval shape and not be too large, so that the workmen can conveniently reach to the centre. Vats provided with mashing apparatus may be either circular or oval. It is advisable to place the mash vat upon a wooden support in a place protected from draught so as to retain the heat of the mash as much as possible.

Fig. 3 shows a mashing machine well adapted for small distilleries.

The vertical shaft, *a*, in the centre of the vat rests in the pillow-block, *b*, and is secured above in the cross-piece, *c*.

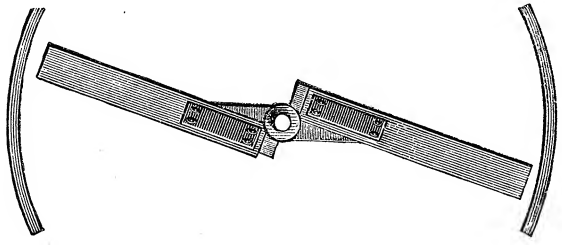
The lower part of the shaft is provided with the casting, *d*, to which are fastened the two wooden arms, *e e*,′ in a position as seen in Fig. 4.

Fig. 3.



By this position of the arms the accumulat on of the heavy parts of the mash in the centre of the vat is avoided.

Fig. 4.



The vertical shaft is set in motion by the bevel gear, *f*, and the horizontal shaft, *g*, which is provided

either with a crank for turning the machine by hand, or, as shown in the illustration, with a fast and loose pulley. The pillow-blocks, *k k*, are connected with the cross-piece, *c*, to which are also fastened the rods, *l*, which, by breaking the rotating motion of the machine, effects a better mixture of the materials.

An excellent but rather expensive mashing machine is shown in Fig. 5. It is intended for large distilleries.

This machine differs from the ordinary ones in that the gearing which sets it in motion is placed under the machine, and is therefore less in the way in emptying and cleansing the vat.

The principal difference, however, is that it is provided with two shafts, the arms of which receive not only a progressive but also a revolving motion.

The following will explain the arrangement:—

The mechanism is set in motion by the shaft, *a b*, which is connected with the engine, and transfers its motion to the vertical principal shaft, *c c*, and the large cog-wheel, *d*, by a bevel gear.

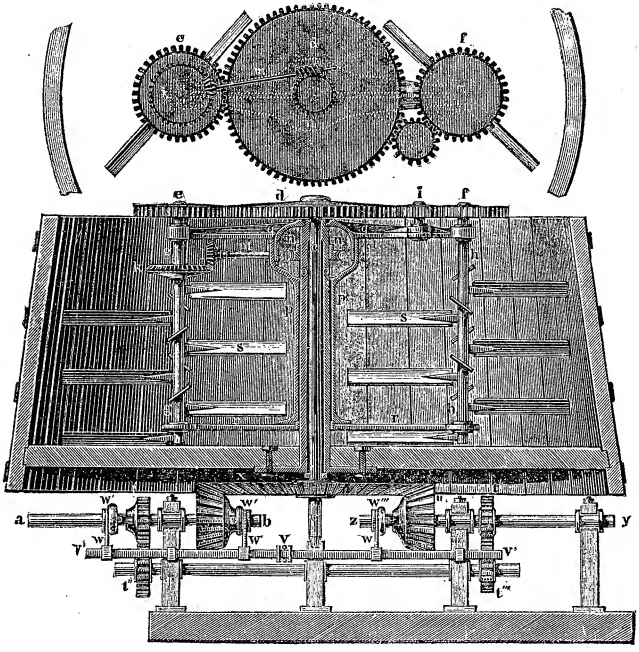
The cogs of the large wheel, *d*, catch directly into the cogs of the small wheel, *e*, of the shaft, *g g*, setting it in motion.

Between the large cog wheel, *d*, and the cog wheel, *f*, of the second shaft, *h h*, is, however, the small cog-wheel, *i*, which transfers the motion from *d* to *f*.

The effect of this arrangement is that the two

shafts revolve in opposite directions, *i. e.*, the wheel, *f*, with its shaft in the direction of the large wheel, *d*, and the wheel, *e*, which stands in direct connection with the large wheel, revolves with its shaft in a direction opposite to that of the large wheel.

Fig. 5.



The described mechanism effects, however, only a rotation of the two shafts around their own axes. To effect at the same time a slow revolution of

these shafts around the principal shaft, *c c*, the conical cog wheel, *k*, is placed on the shaft, *g g*, and, by catching into the small cog wheel, *l*, turns the propelling screw shaft, *m*. The endless screw of this shaft runs in a cog wheel with rounded-off cogs, which sits upon the stationary cast-iron cylinder, *o o*, surrounding the principal shaft, *c c*.*

By the rotation, the screw is forced to run in the immovable cog-wheel, *n n*, in a circle around the principal shaft, and, as the entire screw shaft is of course forced to take part in the movement, it pushes before it the cast-iron cylinder, *o o*, which by means of the arms, *q q*, *r r*, fastened to it, imparts the motion to the shafts, *g g* and *h h*.

This double motion of the shafts causes a very intimate mixture of grist and water.

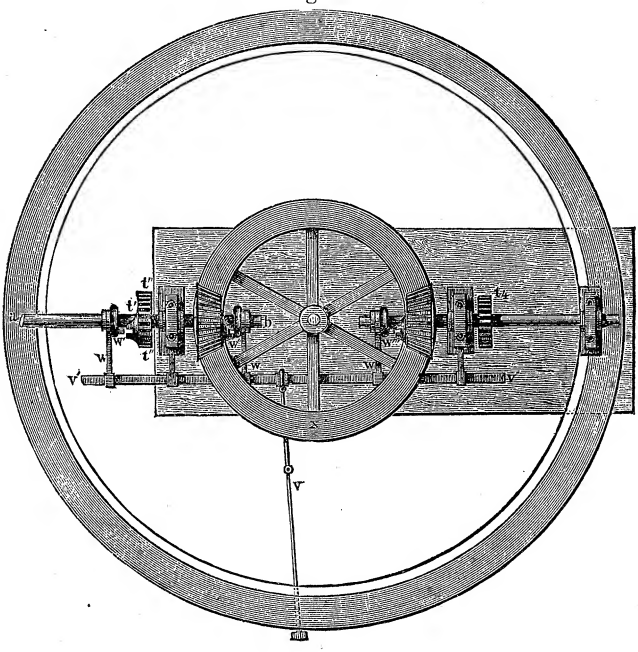
The mechanism of the principal gearing under the mash vat is such that the shafts can be reversed, while the construction of the wheels allows, at the same time, of a slower or quicker movement according as to whether the mash arms, *s*, revolve backward or forward.

The cause of this varying rotation is readily understood by taking into consideration that the moving power can be transferred from the shaft, *a b*, to the vertical shaft, *c*, of the stirring apparatus,

* In the illustration of the gearing the propelling screw-shaft with the wheels belonging to it is so drawn as to show it plainly. It sits of course below the wheels, *d e*, as seen in the cross section.

either by the wheel, t, alone, or by the wheels, t', t'', t''', t^4 and u. The wheels, t, t', and u, are loose upon their shafts and take part in the movement of the latter only when the pins, w', w'', w''', are inserted by the arm of the lever, v, Fig. 6, by means of the arms, $w\,w$, upon the cross rod, $v'\,v''$.

Fig 6.



It will, however, be seen from the illustration that the pins, w' and w''', are thrown out of gear as soon as the pin, w''', takes hold, and *vice versa*.

Hence the revolution of the vertical shaft, *c*, is effected in one or the other direction by the wheel, *t*, or the wheel, *u*. While one wheel is held fast upon the shaft by the pin and the large wheel, *x*, of the vertical shaft, the other wheel becomes loose.

The wheels t', t'', t''' and t^4 form a connected system, their principal purpose being apparently to transfer the motion from the shaft, *a b*, to the shaft, *y z*. But on closer observation it will be found that the wheel, t', is smaller than t'', which causes a decrease in the transferred velocity, and further, that the wheel, t''', is smaller than t^4 by which the velocity is changed for the second time in the same manner, so that when the wheel, *u*, is put into activity the slow movement, mentioned above, takes place, while the movement is accelerated as soon as the wheel, *t*, is put into action.

Besides the parts of the mashing machine described in the foregoing, there is an arrangement by which the movement of the two shafts can be accelerated or checked.

We will now consider the methods of mashing most in use.

Where mashing-in (doughing) precedes the actual mashing, soft, pure water is brought into the mash tun and then the grist is gradually added and mixed with the water until a mass entirely free from lumps is formed. After some time a sufficient quantity of boiling, or nearly boiling, water is

added, with constant and thorough stirring, to bring the mass to the sugar-forming or mashing temperature (64° to 66° C., 147.2° to 150.8° F.). The mash is then allowed to rest as long as is considered necessary for the formation of sugar.

Experienced distillers recognize the temperature at which the most complete formation of sugar takes place (which varies according to the nature of the grain), by the changes which the mass undergoes. It assumes a dark-brownish color and loses the white mealy appearance by reason of the solution of the starch. It becomes a remarkably thin fluid, so that it runs quickly from the mashing oar, whereby the undissolved white germs of the grain become visible. A light white foam of lustrous air bubbles forms upon the surface. The mealy taste changes gradually into a sweet one, and the odor of the mash resembles more and more that of fresh bread.

The indicated phenomena appear sooner with wheat than with rye, and sooner with grain rich in flour and having thin hulls than with grain rich in gluten and having thick hulls. Hence the latter requires a higher temperature than the former.

A very gradual raising of the temperature is considered of great importance. For this reason the operation is frequently interrupted when the mass has been brought to a temperature of 53° to 56° C. (127.4° to 132.8° F.)

The deviations in the mashing process in the

various distilleries are manifold, and consist principally in the quantity and temperature of the mashing-in water, the different manner of mixing the grist with the mashing-in water, the duration of rest for the mashed-in mass, the difference in the temperature of the water added in mashing, and in the time allowed for the formation of sugar.

We give in the following a practical example of the mashing process:—

Each vat of 2300 liters (607.37 gallons) capacity receives a mixture of 275 kilogr. (605 lbs.) of rye, 125 kilogr. (275 lbs.) of barley, 100 kilogr. (220 lbs.) of green malt, and 50 kilogr. (110 lbs.) of kiln-dried malt. 440 liters (116.16 gallons) of water of 60° C. (140° F.), are then brought into the mash vat, and to it are gradually added 50 kilogr. (110 lbs.) of bruised green malt, then 200 kilogr. (440 lbs.) of the grain mixture, 50 kilogr. (110 lbs.) of kiln-dried malt, 200 kilogr. (440 lbs.) of grain, and finally the remaining malt. With good arrangements mashing-in is finished in 30 minutes, so that no lumps are formed, nor does any portion of the grist remain dry. The stirring apparatus is then stopped, and after cleansing all parts of it carefully with a brush, the mass is allowed to rest for one hour, after which 440 liters (116.16 gallons) of water of 90° C. (194° F.) are slowly added, which gives to the mass a temperature of, at the utmost, 70° C. (158° F.). While adding the water the stirring apparatus is run more quickly and, if necessary,

some steam is introduced to attain the desired temperature. During the half hour required for the formation of sugar, the mash will retain a temperature of 65° C. (149° F.); the stirring apparatus being kept in motion during the same time. The walls of the vat are then cleansed and the mash is allowed to stand for two hours, the stirring apparatus being only occasionally revolved.

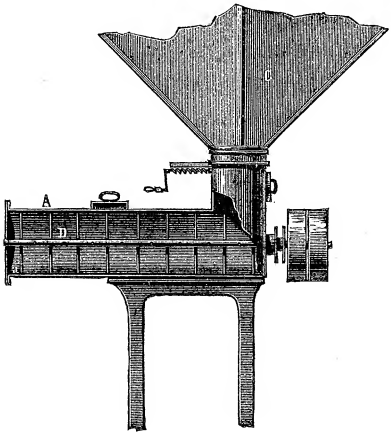
Balling has made experiments with various substances, to be added in mashing, which, by augmenting the yeast-yielding constituents of the mash, cause a more complete attenuation. The best success was obtained with yeast itself. Mix with the mashing-in water, before pouring in the grist, $\frac{1}{50}$ of the weight of the latter of yeast (beer yeast, or better, compressed yeast), and then proceed as usual.

An addition of phosphoric acid, or skimmed milk, has also been found useful by Balling, the latter promoting, in his opinion, the formation of acetic acid.

b. Preparation of clear mashes or mash-worts.— This mode of mashing, which is in general use in English distilleries, consists in the preparation of clear saccharine fluids, freed from grains, which are called worts in distinction from mashes obtained by saccharification. The mash vat is furnished with a false perforated bottom and, in large distilleries, is provided with mechanical arrangements similar to those already described. The grain is

ground fine between millstones, the malt is crushed by passing through rollers, and the mashing is generally effected in Steel's preparatory mashing machine (Fig. 7). The machine stands over the

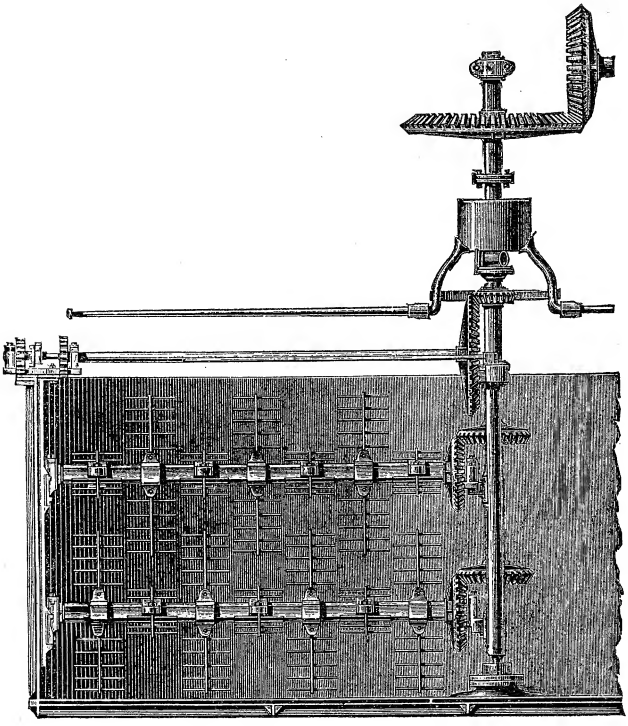
Fig. 7.



actual mash vat and consists of a copper cylinder, *A*, closed on one end and open at *a*. Through the centre of the cylinder passes the shaft, *D*, provided with stirring arms, and making 150 revolutions a minute. The grain is poured in through the funnel, *C*, while the water runs in on the side. The mixture prepared in the cylinder runs into the actual mash vat, generally of cast-iron plates firmly bolted together and provided with a mechanical arrangement as seen in Fig. 8. This apparatus by

rotating horizontally and vertically, effectually agitates the whole of the liquor in the vat.

Fig. 8.



The grist, as previously stated, may be a mixture of different kinds of grain and malt in variable proportions, according to circumstances; 1 part of malt to 2 or 3 parts of the raw ground grain are

considered the best proportions, though 1 part of malt to 5, 6, 8, 9, or even 15 parts of the raw grain is often used.

Suppose 13,000 kilogr. (28,600 lbs.) of grist are used for one operation. The grist is mashed with a sufficient quantity of water at 60° C. (140° F.) to thoroughly moisten it; sufficient water of 80° to 82° C. (176° to 179.6° F.) being then added to raise the temperature of the mash to 65° C. (149° F.). About 709 hectoliters (1871.7 gallons) are required for the entire process, so that the proportion of dry substance to water is about 1 : 5. The perforated false bottom allows the clear wort (mash) to percolate into the space between it and the true bottom of the vat, from which it is drawn off into the underbacks, large vessels placed beneath the mash vat, wherein the worts are collected till pumped into the cooling-backs. After the first wort is drawn off, a like quantity of water of 82° C. (179.6° F.) as used for the first mash, is poured over the grains in the mash vat. The second wort is drawn off in the same manner as the first. The whole of the saccharine and fermentable matters of the grist introduced into the mash vat are generally extracted in three, always in four mashings, but the manner of doing so differs according to the notions of the manager. In some cases the first, second, and third mashings are evaporated till the mixture acquires a specific gravity of about 1.05, when it is thought to be ready for the fermenting

tun, the fourth mash being reserved for extracting fresh quantities of grist.

Other distillers employ such quantities of water in the first and second extracts as will allow the wort to be of a strength fit for fermenting; the third and fourth worts are then concentrated by evaporation to the proper density and added to the first and second; or else are made of the proper strength by running them on fresh quantities of ground malt and grain. Others, again, manage the quantity of water in such a manner that the product of the first extract has the density necessary for fermentation, the remaining three extracts being rendered stronger either by evaporation or mashing with fresh portions of malt or grist.

Distillers and brewers are more variable in their mode of working than any other class of manufacturers who carry on business on a large scale. In no one operation do they seemingly follow a common rule, each having some favorite plan of his own of a supposed greater merit than others; hence the great difficulty of giving a true and comprehensive detail of these branches. To illustrate the manner of preparing clear mashes, we give in the following a practical example.

For every 100 kilogr. (220 lbs.) of malt used, 150 liters (39.60 gallons) of water of 70° C. (158° F.) are brought into the mash vat. After thorough mashing, 90 liters (23.77 gallons) of nearly boiling water are added, and after again mashing, the mash

is allowed to rest, when the resulting 125 liters (32.8 gallons) of clear wort of 16 to 18 per cent. are drawn off. 110 liters (29.05 gallons) of nearly boiling water are then immediately poured over for the second wort, thoroughly stirred and allowed to stand one hour, when the clear wort amounting to about the same quantity as the first, is drawn off. The two hot worts are mixed and quickly reduced to the fermenting temperature by means of suitable coolers. The grains remaining in the mash vat are once more extracted with hot water, and finally washed with hot water. The third and fourth extracts are reserved for extracting fresh quantities of grist.

The mixture of the first two worts shows, in this case, 13 to 14 per cent., and attenuates in 4 to 9 days. The attenuated mash is called "*wash*."

In distilleries provided with several mash vats, the third wort is allowed to run immediately on fresh grist, in another vat to prepare the first wort, the last mashing water being taken for preparing the second wort, and so on.

In a large Scotch distillery 260 cwt. of grist, including a sixth or a fourth of malt, are taken for an ordinary mash. They are put into the mash vat, and about 788 barrels* (28,368 gallons) of water are poured upon them at two stages of the

* 9 gallons make 1 firkin
2 firkins " 1 kilderkin
2 kilderkins " 1 barrel

operation. The first water is employed at 60° C. (140° F.), the second water at 79° to 82° C. (174.2° to 179.6° F.); the whole contents of the vat being brought to 65° C. (149° F.).

In the Dublin distilleries about seven-eighths of raw grain are employed. The first mash is the only one let into the fermenting vat, the succeeding small worts being kept for the next day's distilling. In preparing the wort about 5 barrels (180 gallons) of water are taken to the quarter (8 bushels) of grist, but more if small worts are used. To completely exhaust the grist about the same amount of water is required for the last mashing.

The temperature of the water is made to depend on the quantity of malt present; when the malt and raw grain are mixed in the proportion of 1 of malt to 2 of grain, the first mashing may be made at a temperature of 65.5° to 71° C. (150° to 159.8° F.); but if the malt and grain be as 1 to 4, 6 to 9, then the water should not exceed 62.5° C. (144 5° F.) for the first mashing, in order to prevent the "*setting*" of the mash. From one hour and a half to two hours generally suffice for the mashing operation, when the contents of the mash-vat are kept in agitation by machinery, and the proper heat of the water has been attended to; though sometimes the time occupied extends to three or more hours.

The principal advantage of preparing clear mashes or worts is, that all insoluble admixtures injurious to the purity of the product are kept

away from the fermenting mash, since the oils of a peculiar and always disagreeable odor are developed from the grains only. A further advantage is that clear worts enable the distiller to make use of any kind of distilling apparatus, even one heated by an open fire, while thick mashes require stills of special construction. But the yield of alcohol obtained from them is never as large as that from thick mashes, as it is scarcely possible, except with very complicated arrangements, to extract everything that has become soluble during saccharification. Besides, all the starch of the grain is never entirely converted into soluble products, and, as it has been proved by many experiments, that a portion of the starch remaining undissolved becomes of service during fermentation, it will be readily seen that this portion is entirely lost, as regards the gaining of spirit, as well as a portion of the starch dissolved during the mashing process. Finally, the preparation of clear mashes or worts requires, in all cases, more complicated arrangements and more manual labor than that of thick mashes, so that it cannot be claimed to possess any advantage even where the revenue laws allow the distiller to work worts which are, of course, more dilute than thick mashes.

3. *Cleansing the Utensils.*

Whatsoever the method of mashing in use, the vessels and utensils used in the operation must be

thoroughly cleansed, as soon as the process is finished. Every particle of mash adhering to the vat and utensils, until the next operation, would inevitably turn sour, and transfer ferments of acetous fermentation into future mashes, the effect of which would be lactic acid fermentation, and consequently, loss of alcohol, which would constantly increase with continued work. The vats, etc., should therefore be thoroughly cleansed with water, the greatest care being used to be sure of success.

As an excellent means of cleansing, and preventing, at the same time, the formation of mould and acid, Maerkel recommends an addition of carbolic acid to the water used in cleaning the malt cellar and fermenting room. It does also excellent service when mixed with the lime used in whitewashing the rooms.

Where special causes demand an exceptional cleansing, Böhm recommends, after the use of all customary means, to whitewash the vessels, and after allowing them to stand for one hour, and then rinsing out with pure hot water, to pour alcohol upon the sides and bottom of the vessels, and ignite.

4. *Cooling the Mash.*

The temperature of the mash, after complete saccharification, being still 50° C. (122° F.), it has to be cooled off before it can be brought into fermentation. This is effected either in coolers or refrigerators.

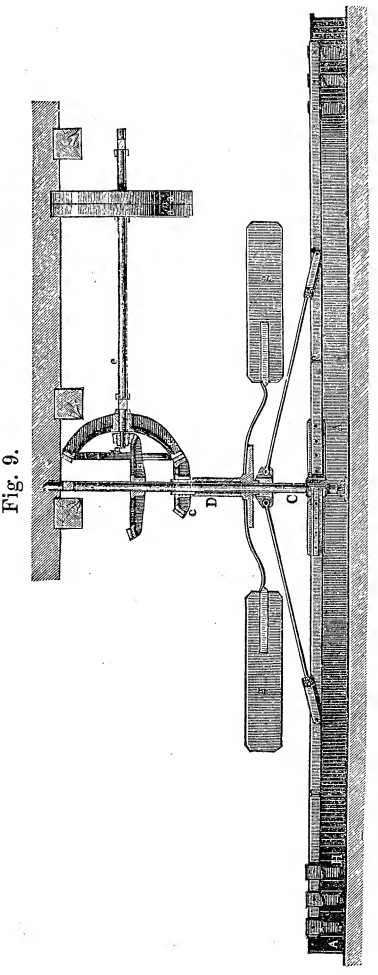


Fig. 9.

Coolers are shallow rectangular vessels of wood or iron, into which the mash is pumped to the depth of two, three, four, or more inches. The laborious work of stirring the mash by hand with rakes is now generally superseded by mechanical arrangements. Fig. 9 shows a cooler much in use. The iron cooler, *A*, rests upon a framework placed in the open air, or at the upper part of the building, in such a manner as to be exposed to the most prevailing wind. It is covered by a light roof to keep off the rain. The shaft, *C*, drives the stirring apparatus, and the hollow shaft, *D*, the *flighters*, machines like horizontal windmills. *a a'*, are pulleys, one loose, the other fast, the latter setting the horizontal shaft, *e*, in motion. The shaft, *e*, bears the small cog-wheel, *b*, which catches into the large cog-wheel, *b'*, fastened to the shaft, *C*. By this translation the shaft, *C*, is set in motion, but its revolving velocity is much slower than that of the shaft, *e*, as the small cog-wheel, *b*, must, for instance, make 61 revolutions before the wheel, *b'*, turns 10 times around its axis. On the end of the hollow shaft, *D*, sits the small conical cog-wheel, *c*, which gears into the larger wheel, *c'*, which sits upon the principal shaft, *e*. The shape of the two wheels, *c c'*, effects a slow rotation of the flighters. On the lower end of the shaft, *C*, are two long iron arms, *F*, reaching over the entire length of the cooler. On the arms are fastened a number of three-cornered shovels, *H*, which almost touch the bottom of the cooler, and

constantly stir up the mash when the arms, *F*, are revolving.

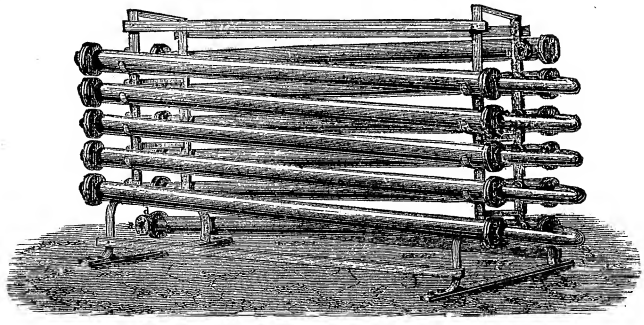
On one side of the cooler is an opening closed by a valve through which the mash is directly conducted into the fermenting vats by means of a pipe.

The time of cooling is now much shortened, and the waste of heat lessened by causing the mashes to pass through tubes surrounded by a stream of cold water. By these machines, which are called refrigerators, the mash may be cooled down to the temperature of the surrounding water, or any other intermediate degree that may prove most advantageous. Mashes cooled down by this means lose none of their water by evaporation, as they do if cooled in the shallow iron coolers previously described, and consequently, with the exception of the little alteration in gravity, occasioned by the difference of temperature, the mashes remain of the same density as they indicated when admitted into the refrigerator.

Nägeli's refrigerator, Fig. 10, consists of two concentric tubes, 0.1 and 0.14 meter (0.32 to 0.45 foot) in diameter, leaving an intermediate space of 2 centimeters (0.78 inch). The inner tube through which the mash passes is of copper and the outer one of iron, while the cooling water is conducted through the intermediate space. To give the pipes as great a length as possible with a small consumption of space, the refrigerator receives the form as seen in the illustration. The water enters

at *a*, and after washing around all parts of the apparatus, leaves it heated at *d*.

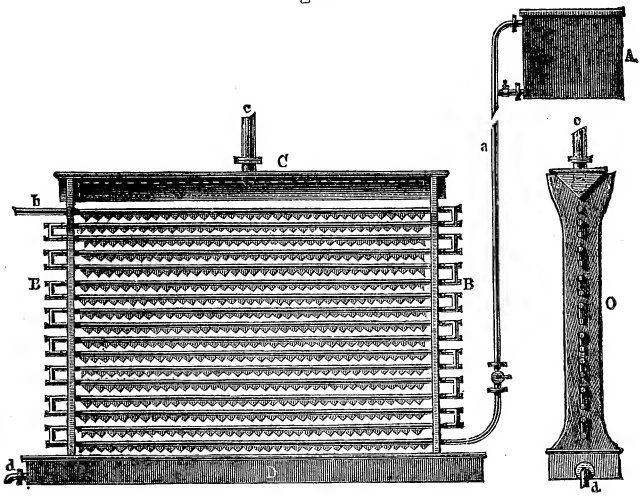
Fig. 10.



Thin mashes or worts are especially adapted to cooling in refrigerators. Fig. 11 represents a cooling apparatus much used in English distilleries, which possesses the advantage that the evaporation of the cooling water contributes largely to the cooling of the wort. From the reservoir, *A*, the wort runs through *a* into the serpentine tube, *BB*, composed of a large number of straight joints, and runs off at *b*. The cold water drips from the perforated reservoir, *C*, upon the top-pipe, and over it, following the saw-toothed projections upon the next pipe, and so on, so that a constant and abundant shower of water, becoming warmer towards the bottom of the apparatus is formed, which collects in *D*, and runs off at *d*. It will be seen that the water must evaporate on the surface of the pipes, which it

covers in a thin layer, and consequently withdraws heat from the mash; besides, the coldest water comes always in contact with the pipe containing the mash cooled off the most.

Fig. 11.



To what degree must the mash be cooled? The temperature required varies, and depends chiefly on the temperature of the fermenting room, the size and height of the fermenting vats, the nature of the ferment and the time in which fermentation is to be completed.

The higher the temperature of the fermenting room, the lower the temperature must be at which the mash is brought into fermentation.

The larger and less shallow the fermenting vats are, and the less cooling off takes place by conduction, the more the temperature rises in the course of fermentation, and the lower must be the temperature at which the mash is brought into fermentation.

The longer the fermentation is to last, the lower must be the temperature of the mash when brought into fermentation.

The duration of fermentation depends much on the revenue laws of the different countries. In most parts of Germany, for instance, the duration of fermentation is restricted to 3 or 4 days; in Belgium fermentation must be complete in 24 hours, as the revenue is paid for the vat on the basis of 24 hours for the completion of the process.

For a 3 days' fermentation in the cold season of the year, the mash may, as a general rule, be brought into fermentation at 22° to 25° C. (71.6° to 77° F.), and in the warmer season at 20° to 22° C. (68° to 71.6° F.); for a four days' fermentation in the cold season of the year at 20° to 22° C. (68° to 71.6° F.), and in the warmer season at 18° to 20° C. (64.4 to 68° F.). For a fermenting room with a temperature of 12° to 15° C. (33.6° to 59° F.), a temperature of 20° to 21° C. (68° to 69.8° F.) will generally be required for a four days' fermentation.

5. *Fermentation of the Mash.*

Fermentation is the most important stage through which the materials in the hands of the distiller have to pass, and one which not only demands considerable skill and attention for its proper management, but also requires extensive knowledge, both of the principles of chemistry, and of practical results. Indeed, the success of the operation almost entirely depends on the fermentation of the mash; and unless managed with due care and dexterity, a failure will be the consequence. Beer yeast was formerly exclusively used, and this and compressed yeast are still used in many places where they are good and cheap and allowed by the revenue laws.

The quantity of yeast required does not increase in the same proportion as the quantity of mash to be fermented. If 8 to 10 liters (2.11 to 2.64 gallons) of yeast are required for 1000 (264.12 gallons) of mash, 12 to 15 liters (3.17 to 3.96 gallons) will suffice for 2000 liters (528.25 gallons).

In working thick mashes the temperature exerts great influence upon the yield; whenever possible the mash should not be brought into fermentation at a higher temperature than 17.5° C. (63.5° F.). Thick mashes brought into fermentation at over 20° C. (68° F.) show mostly incomplete attenuation, because at a high temperature the lactic acid ferment develops too much, and a smaller quantity of alcoholic yeast is formed.

With good mash and ferment, and a suitable temperature, fermentation commences in two hours. A white foam of small bubbles of carbonic acid forms upon the surface, first in the centre and then on the edge of the vat. In a few hours the entire surface is covered, and the carbonic acid appearing now in greater abundance, forces the undissolved substances of the mash, grains and hulls, to the surface, which form a strong cover.

The constantly increasing action of the yeast shows itself in the increase of the temperature and stronger development of carbonic acid, and in about 16 hours the most vigorous and active fermentation takes place, which lasts for about 10 hours. The temperature rises 15° C. (59° F.), and a pungent, vinous odor is perceived.

After this period, fermentation becomes gradually quieter; the pungent odor disappears and the temperature falls. The motion of the mash becomes more gentle and finally ceases entirely. The surface is covered with a solid coat of hulls, which should be preserved until the wash is distilled.

Should fermentation flag it is almost a hopeless task to restore vigorous action. Some distillers try the addition of mash brought into a rapid state of fermentation in a tub by a large portion of yeast, but this plan is seldom successful.

The most vigorous fermentation is that in which the frothy cover of hulls is kept in a constantly rolling motion, rising on one side of the vat and

falling down on the other. In another form of fermentation, the cover is lifted by the carbonic acid and falls after the latter has forced a passage; or the mash intumesces like fermenting flour-dough, and, after raising up, falls suddenly, the rising and falling being repeated in quite regular periods. The mash frequently spurts up high and shows a vigorous splashing. Both of these fermentations give good results, the latter showing itself especially in thick mashes, and is claimed to be produced by the addition of crushed oats in mashing.

Fermentation without the formation of a cover is always feeble and yields poor results.

There are many opinions about the advisability of covering the fermenting vats during fermentation. The best plan, in our opinion, is to cover the vats when the ferment has been added to the mash, in order to prevent the temperature from falling until fermentation sets in, when the cover should be removed to avoid too strong heating. When fermentation becomes less vigorous, replace the cover to prevent the access of atmospheric air, the oxygen of which readily converts the alcohol into acetic acid during this period. Formation of vinegar is detected by the increasing specific gravity of the mashes, and the peculiar aroma of acetic acid. The vats are made air-tight by means of a well-fitting cover, through which a large tube passes and enters the bottom of a large tub placed over the fermenting vat; the rising yeast and froth are forced

through the pipe into the open tub, and when the fermentation slackens, these matters return into the vat. Many distillers smear the edge of the vat with tallow, butter, or rich cream, to keep the mash from overflowing the vat, while others sprinkle some oil or melted tallow upon the rising mash, which effects a sudden bursting of the bubbles filled with carbonic acid. In general the fermenting vats are conical vessels of much larger capacity than required to hold the mash when first introduced, and thus serve the double purpose of containing the froth, and preventing the escape of the heat generated during the process. At present, in the larger distilleries, the fermenting vats are of iron, with an outer casing of wood. They are much more easily managed than the wooden ones, the iron having a greater conducting power. Should the heat of the mash get too high, cold water is introduced into the space between the casing and vat; and if too cold, it is readily brought to the proper temperature by supplying the jacket with hot water.

The great disadvantage of wood as a material for fermenting vats, is that, on account of its porosity, it absorbs mash, which, after emptying the vat, becomes sour and exerts an injurious influence upon the succeeding operation. To prevent this, the vat should be carefully cleansed with water and brushes, and occasionally whitewashed, and again thoroughly scrubbed. To prevent the

absorption of mash it has been recommended to coat the inner surface of the vat with a varnish, it being, of course, necessary that the vats should be entirely dry. The following preparation has stood a practical test, and can be recommended for the purpose: Digest 100 grammes (3.5 ozs.) of shellac, and the same quantity of dammar resin in 2 liters (2.11 qts.) of alcohol in a well-closed bottle, which should be put in a warm place until the greater part of the resins has been dissolved. Shake the bottle frequently. The varnish or glaze is ready for use when a turbid fluid has been formed, which does not require filtering. A coat of varnish is then applied, and set on fire when it has dried so far that it no longer runs. When it burns brightly, the cover is placed tightly upon the vat to extinguish the flame, and the vat is allowed to cool off with the lid on. A thin layer of the varnish will remain adhering so tightly to the sides of the vat, that it will not crack off.

Fermenting vats constructed of glass plates have been recently used with excellent success. They possess invaluable properties, but the difficulty of constructing such large vessels of glass, and their consequent costliness, will very likely prove a serious hindrance to their general introduction.

II. Preparation of Vinous Mash from Maize or Rice.

As maize can be crushed and ground, and has the same chemical composition as grain, its conversion into sweet mash cannot vary essentially from the process employed for wheat, rye, etc. The maize is mixed with malt. The modification which takes place is due to the hard, horn-like nature of the grains. Maize must be crushed and ground fine, and, by bolting, converted into meal. The loose condition required for the mash is obtained by the use of green malt, or dry malt crushed between rollers. Mashing maize in the customary manner by mashing a mixture of maize meal and crushed malt, and then adding hot water, the conversion of the starch of the maize into sugar would be incomplete, on account of the insufficient softening of the maize-substance. Hence the maize meal is first mashed-in by itself, in warm water, and the temperature of the mass is then gradually raised to 80° to 90° C. (176° to 194° F.), which will effect a complete softening. The mass is next cooled off, and the malt, previously mashed-in in cold water, is finally added. Maize requires at least two and one-half times its own weight of water for mashing-in, though the proper proportion depends on the nature of the different varieties of maize.

The water for doughing-in is taken at a temper-

ature of about 68.7° C. (155.7° F.), so that, after the meal has been gradually poured in, the doughed-in mass shows a temperature of 59° to 61° C. (138.2° to 141.8° F.) Should the distiller hesitate to bring the meal in immediate contact with water of such a high temperature, the water may be divided into two portions; the meal is then poured into the first and larger portion at 38° C. (100.4° F.), and the other portion, having a temperature of about 87° C. (188.6° F.), is added after some time. Hamilton recommends the use of water of not more than 45° C. (113° F.), so that after doughing-in the mixture shows a temperature of 42° C. (107.6° F.) He claims that by this means, and the very slow addition of steam for further heating, the formation of lumps in the mash can be best avoided. The doughing-in requires 20 to 30 minutes.

The softening of the doughed-in maize cannot very well be accomplished with boiling water, as too large a quantity would be required; steam has therefore to be used. When the mass attains a temperature of 72° C. (161.6° F.), it commences to swell, and, should too little water have been used for doughing-in, it will be impossible to work it any further. The proper softening of the starch granules, which is recognized by a peculiar aromatic odor and by pressure with the fingers, is only attained at a temperature of over 82° C. (179.6° F.) In introducing steam the mass spurts

up as soon as the temperature is more than 62° C. (143.6° F.) Hence the mash vat, if provided with a stirring apparatus, is covered, or if the mashing is done by hand, the place where the steam-pipe enters the mash vat is covered, or a cover consisting of two halves and provided with two slits for the passage of the thin ends of the mashing-oars, is placed upon the vat. Hamilton recommends the keeping of a board, several feet square, floating upon the surface of the mass over the opening of the steam pipe.

The mass, when thoroughly softened, must be quickly cooled off to the temperature at which the formation of sugar takes place (63° C., 145.4° F.), which is effected by vigorous stirring or a cooling apparatus. After adding the malt, previously mashed in with cold water, and thorough mashing, the mash is allowed to stand a few hours for the formation of sugar, the vat being covered to retain the required temperature.

The quantity of malt varies very much. While some distilleries use but $\frac{1}{8}$ of the weight of maize, others take $\frac{1}{7}$, $\frac{1}{6}$ to $\frac{1}{4}$. It is also customary to add some rye-grist, which it is claimed promotes fermentation. The rye-grist is doughed-in, and, after sufficient cooling of the maize, added either before the malt, or doughed-in with the latter, and the mixture added. In a large Hungarian distillery 14 parts of maize, $2\frac{1}{2}$ of malt, and 3 of rye are used.

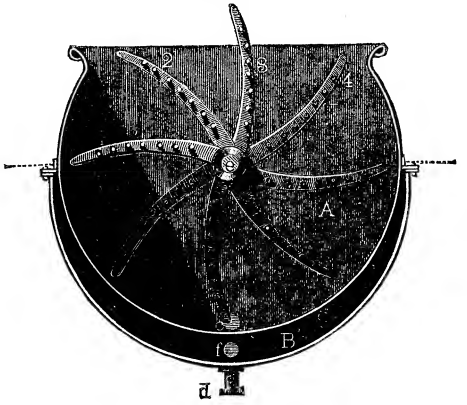
From 12.5 to 14.3 per cent. of dry malt corresponding to 15.63 to 17.8 per cent. of barley is used when no rye is added. Of green malt at the utmost 16.7 per cent. corresponding to 11.1 per cent. of barley is required.

Modifications of the mashing process occur but seldom. The method of adding a small quantity of malt to the maize meal in doughing seems to us a very rational one, as the diastase present, by liquefying the finer particles of the meal in the slow softening process, renders the mass less thick. Some persons dough-in mash and malt simultaneously, though this cannot be recommended, if our opinion, that the diastase loses its effects at a high temperature, be correct.

The Belgian mashing apparatus (Fig. 12), which allows of a convenient heating and cooling of the mash, is especially adapted for working maize. It consists of a horizontal sheet-iron cylinder closed on both ends by vertical sides and provided with stirring apparatus and jacket. Fig. 12 shows a cross section of the apparatus. *A* is the inner space, *B* the space between the cylinder and jacket, *c* a wide opening for drawing off the mash, and *d* an opening for letting off steam or water from *B*. *e* is the shaft of the stirring apparatus which passes through stuffing boxes in the sides of the cylinder and projects sufficiently on one side to carry the pulley. The shaft makes 26 to 28 revolutions a minute.

1, 2, 3, 4 are arms fastened to the shaft. They carry small iron cross rods, so that each arm acts as a frame. This arrangement is also modified so that each arm forms a grating by means of cross rods,

Fig. 12.



which are made so wide as to project one over the other, by which a more effective working of the mash is accomplished.

The water passes into *B* at *f*, and passes out at the upper part of *B*. The length of the cylinder is about 2 meters (6.56 feet).

By introducing steam or cold water in the space, *B*, the contents of the apparatus can be kept at any desired temperature, while the stirring apparatus effects the mixture of water and maize meal.

In Hungary, where the distilling of maize is carried on very extensively, the use of dissolved

sulphurous acid has been widely introduced. The principal object of its employment is to increase the yield, which is generally obtained, while the other advantages claimed for it seem to be less substantiated. Perhaps other acids, more easily applied, might prove of as much advantage. Sulphurous acid is, however, exclusively used for the purpose of improving the mash, and consequently saccharification and fermentation. The presence of acid especially promotes the formation of a homogeneous paste free from lumps; hence it is employed by using water, which has absorbed sulphurous acid, instead of ordinary water.

To saturate the water with sulphurous acid, sulphur is burned in a suitable oven, and a finely divided stream of water directed against the current of gas formed, and the acidulated water collected in the lower part of the absorbing column of cast iron, wood, or burned clay. The other parts of the oven consist of iron with a coating of clay and iron filings mixed with vinegar.

The proportion of sulphur used should be so regulated that the solution of the acid contains from 60 to 120 grammes (2.11 to 4.23 ozs.) of sulphur to every 100 kilogr. (220 lbs.) of maize.

The maize meal is placed in large vats and allowed to stand covered with the acidulated water for 24 hours. A remarkable change takes place during this time; the mass turns yellow, and all hard and solid parts feel soft and fatty to the touch.

When this is the case soaking should be interrupted, as otherwise putrid fermentation may easily set in. The mass is then brought into large iron vats, and, after adding sufficient water to form a stiff paste, heated by steam to 87° or 88° C. (188.6° or 190.4° F.), being constantly stirred by mechanical appliances.

The sulphurous acid, being volatile, of course escapes during this operation, only the portion fixed on bases, and perhaps converted into sulphuric acid, remaining, which is, however, sufficient to answer the purpose.

The heated mass is allowed to stand 1 to 2 hours. In the mean while the required crushed green malt is mashed-in in the mash vat with cold water, and the maize mash gradually added with vigorous stirring and heating to 65° C. (149° F.)

The mash shows generally 13 to 14 per cent., and fermentation is completed in 16 to 18 hours. During fermentation the temperature of the mash rises to 40° C. (104° F.), a thick layer of reddish oil forming upon the surface.

The working of maize is carried on in a very simple manner in Italy. While a number of distilleries effect saccharification by the use of sulphuric acid, more modern ones use barley malt. The maize is converted into a fine powder, soaked in water for 24 hours, and then thoroughly boiled for several hours by the introduction of direct steam. The intumesced paste-like mass is then

cooled, compounded with barley malt, and, after saccharification is complete, brought into another cooler and cooled to about 30° C. (86° F.). The artificial yeast prepared from kiln-dried ground malt is then added, and the mash, showing about 12 per cent. by the saccharometer, subjected to fermentation, which lasts about two days, and brings the mash to 0 per cent.

In another distillery, saccharification is effected by the use of germinated maize without the addition of barley malt.

In malting maize it is desirable that it should germinate quickly and the radicle be developed as long as possible. The maize is soaked 4 to 5 days in winter and 26 to 36 hours in summer, the time depending much on the hardness and temperature of the water used. The soaking water is changed every 14 hours in summer, and every 24 to 30 hours in winter. The soaked maize is piled up until it becomes heated, or, better, until it spires; the height of the pile depends on the local temperature and the season of the year, but the pile must always be carried warm. When a thorough sweat shows itself on the surface, the pile is turned over with a shovel. The malt can be used in winter in 6 or 7 days after soaking the maize, and in summer on the fifth day. The malt is ground, with a constant admission of cold water, to a fine paste in a mill of two stones, and added to the mash, it being

advisable to grind it shortly before use, as it passes quickly into fermentation.

What has been said in regard to the mashing of maize applies, in general, to that of rice. The hard, horny nature of many varieties renders the conversion into flour absolutely necessary. Continued soaking and scalding before adding the malt are also required for the complete conversion of the starch into sugar. To effect liquefaction and avoid the formation of a thick, pasty mass, the addition of a small quantity of malt in scalding is recommended. Rice-spirit has a very fine and pure odor, and brings a higher price than the ordinary product, while the grains yield an excellent fodder.

III. Preparation of Vinous Mash from Potatoes.

The active principle by which the starch of the potato is converted into dextrose, is diastase, but this substance is not found even in the germinated potato. To convert the starch into dextrose it is therefore necessary to add malt, or to treat the potatoes first with dilute sulphuric acid. The first method is most generally used, which includes the following operations: 1. Washing, 2. Boiling, 3. Chopping of the boiled potatoes.

1. *Washing.*

In all large distilleries a washing machine similar to that in beet sugar factories is used. It is very

suitable to connect with the washing machine an apparatus for removing stones frequently found among potatoes, as they are very troublesome in the succeeding operations of boiling and chopping. Siemens's washing machine may be especially recommended for the purpose, as it accomplishes a perfect separation of the stones.

2. *Boiling or Steaming the Potatoes.*

The potatoes are placed in a large wooden vat, and boiled by the introduction of steam. When the potatoes are done the steam pipe is closed as far as to admit only sufficient steam to keep up the boiling temperature in the barrel, and the chopping of the potatoes is at once proceeded with.

3. *Chopping the Boiled Potatoes.*

This is effected by passing the boiled potatoes between two hollow cast-iron cylinders, the axles of which are so arranged and fitted in a frame-work as to admit of the cylinders being moved in opposite directions, and thus capable of converting the boiled potatoes into a uniform mash. The chopping machine is placed immediately over the mash vat, which stands either below or alongside the boiling vat so that the boiled potatoes fall from the boiling vat into the hopper of the chopping machine.

Fig. 13 explains the arrangement.

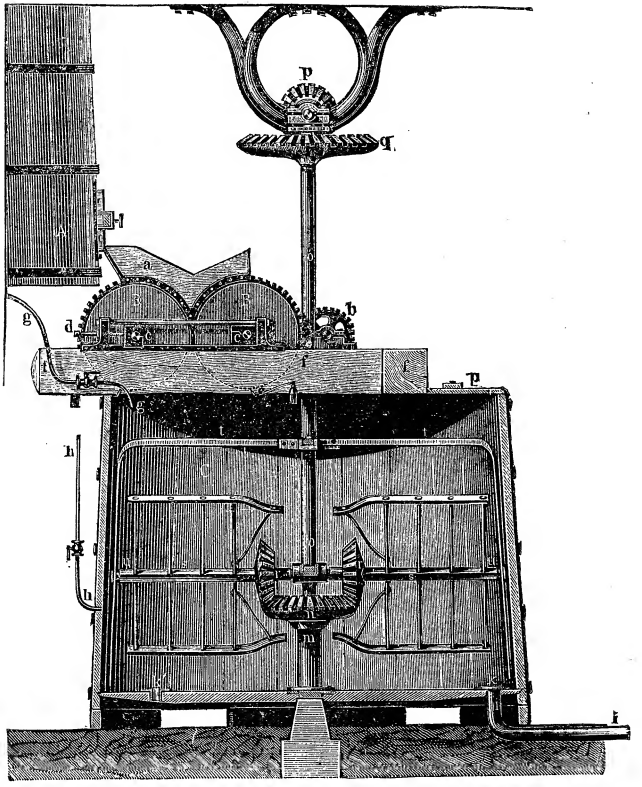
A is the vat for boiling the potatoes.

B B are the chopping rollers.

C is the mash vat.

The arrangement will be understood from the following description :—

Fig. 13.



a is the hopper over the chopping rollers; *b* is a small spur wheel whose teeth catch into a larger

one sitting upon the shaft of one of the rollers and imparting motion to it, which is transferred to the other roller by means of a large cog-wheel fastened to its shaft.

c c are the journals of the roller shafts; *d* the arrangement by which the distance between the rollers is regulated.

f f is a strong wooden frame supporting the journals of the roller shafts and of the wheel, *b*.

g g is a pipe provided with a cock for supplying the mash vat with water.

h h is a pipe provided with a cock for the introduction of steam into the mash vat.

i i is the pipe for discharging the mash from the mash vat, and

k the valve closing the pipe; it is lifted out with a hook when the mash is to be drawn off.

m is a stationary iron beam with the immovable bevel gear, *n*, in the centre of which is the bearing of the vertical shaft, *o o*, of the stirring apparatus, which receives its revolving motion through the bevel gear, *p q*.

r r are conical wheels upon the horizontal revolving arm-shafts, *s s*. The cogs of this wheel catch into those of *n*. The arm-shafts have their inner centre of motion on the shaft *o*, and their outer at *a*, on the shaft, *t t*.

The manner in which the stirring apparatus works is readily understood. When the vertical shaft, *o*, revolves, the wheels, *r*, catch into the

wheel *n*, and cause the horizontal arm-arrangement to revolve.

The mashing process varies very much. Of the numerous modifications we give only a few which most deserve attention.

a. About half an hour before the potatoes are done, 16 to 18 liters (4.22 to 4.75 gallons) of water of about 15° to 25° C. (59° to 77° F.) for every 100 kilogr. (220 lbs.) of potatoes, are brought into the mash vat, and, after pouring in the entire quantity of ground air-dried malt, or of finely crushed green malt, the whole is vigorously stirred. The malt is sometimes rye-malt, sometimes barley-malt, and generally a mixture of the two. Green malt has greater power of conversion than air-dried malt, ultimately producing a larger quantity of alcohol. The proportion of crushed malt to be employed varies in many instances; in some cases only 2 to 3 per cent. of barley-malt is added to 100 parts of potatoes; in others as much as 10 per cent. is used. A medium quantity between these two extremes, or about 5 per cent., is most in use. When the potatoes are done, the door of the boiling vat is opened and the potatoes are gradually drawn into the hopper of the chopping machine by means of a long hook, the chopped potatoes falling into the mash vat. When all the potatoes have thus passed through the chopping machine, the mashing is continued for some time. When mashing is finished, the temperature of the mash *must*

be 63° to 65° C. (145.4° to 149° F.) This is absolutely necessary, and the quantity and temperature of the mashing water and the rapidity with which the potatoes are passed through the chopping machine must be regulated accordingly. Practice teaches this in a few days; nothing more especial can be said about it.

The above temperature must not be exceeded during mashing, and in order to avoid it, occasional use of the thermometer should be made. If there is any danger of the temperature rising too high, the chopping of the potatoes must be interrupted and the mash thoroughly stirred, and, in the worst case, some cold water added to it.

After mashing is complete, the mash vat is covered, and the mash is allowed to rest two or three hours for the formation of sugar.

b. Of the many mashing methods recommended we mention that according to Gumbinner:—

When the potatoes are done, a few bucketfuls of lukewarm water are poured into the mash vat, and chopped potatoes added until the mass can no longer be worked with facility, and shows a temperature of 50° to 60° C. (122° to 140° F.) The fourth part of the malt grist required is now scattered over the mass and the whole thoroughly worked with the stirring apparatus, the door of the boiling vat remaining, in the mean while, closed. In two or three minutes the chopping of the potatoes is continued until the temperature in the mash vat

has risen to 60° to 62° C. (140° to 143.6° F.), when the second quarter of the malt grist is scattered over the mash and thoroughly mixed with the contents of the mash vat. The chopping of the potatoes is again interrupted during this operation.

The third and the last quarter of the malt grist are added in the same manner whenever the temperature of the mash is 60° to 62° C. (140° to 143.6° F.)

The temperature of the mash must not exceed 62° to 63° C. (143.6° to 145.4° F.), it being best to keep it at 61° C. (141.8° F.). Should the mash become too hot by the addition of chopped potatoes, the operation must be interrupted and the mash thoroughly stirred until sufficiently cooled. The final temperature in mashing should be 61° C. (141.8° F.)

The mash-vat is now covered with a well-fitting cover, which is removed after exactly half an hour, and the mash stirred until it shows 58° C. (136.4° F.) It is then allowed to stand uncovered for one hour, and stirred once more, though too strong cooling off should be avoided.

When saccharification is complete, the mash is cooled and conducted to the fermenting vat. The proportion of yeast to be added is, as experience has shown, at least 0.5 kilogr. (1.1 lbs.) of compressed yeast to every 100 kilogr. (220 lbs.) of mash from potatoes and malt. The potato mash contains, besides the husks of malt and grain,

some finely divided cellular tissue; these substances, during fermentation, are carried to the surface of the mash and form a scum, the appearance and behavior of which give an opportunity of judging the progress of the fermentation. Under normal conditions the development of carbonic acid appears inside of two hours, and produces a light, white froth. In the course of six hours, the mash rises up, and a cover of husks and cellular substance is formed. Mash correctly treated, and brought into fermentation at the lowest temperature admissible, will always pass through a quiet progressive fermentation, decreasing in the same proportion as its increase. The scum which appears on the surface sinks, or is drawn down at one side of the vat and thrown up at the opposite side, while bubbles of air or gas appear and burst on the surface, much as baker's dough heaves under the influence of the ferment. In about 16 hours after bringing the mash into fermentation, the yeast acquires its greatest activity; the most vigorous period of fermentation commences, lasting 20 hours, during which the temperature of the mash rises about 12° to 15° C. (53.6° to 59° F.), and a pungent odor, originating from the escape of carbonic acid, is perceptible.

The violence of the fermentation abates gradually, the visible motions upon the surface of the mash become weaker and weaker, the pungent

odor disappears more and more, and the temperature falls a few degrees.

The surface of the mash becomes finally entirely quiet; the skins and solid constituents of the potatoes reappear on the surface and form a solid cover.

With a regular fermentation, as described above, the distiller may be assured that all fermentable constituents will be decomposed, and all the sugar be converted into alcohol and carbonic acid.

Irregular fermentation is so far opposed to the regular course, that the surface of the mash is only partly covered with froth, which remains in one position, and does not move itself. The result of such a fermentation is generally defective, the reason being the incomplete saccharification of the mash, the addition of too small a quantity of yeast, or, finally, working at too low a temperature.

The greatest danger, as regards the yield of alcohol, is found in the appearance of so-called viscous fermentation, which is very likely produced by an excessive development of other ferments present besides the alcoholic ferment. For practical purposes it is sufficient to know that it is chiefly caused either by the vats not being thoroughly clean, or by the use of spoiled ferment. Fermentation produced by either one of these causes increases gradually, until the mash becomes actually so viscous and ropy that a large portion runs over and is lost. Fermentation producing

lactic and butyric acids belongs practically to the same order of phenomena. All means proposed, which generally consist in the addition of certain quantities of mash, are entirely worthless, the only remedy being a change of the ferment, thorough washing of the fermenting vats and other utensils, etc. Cleanliness and a somewhat lower temperature are the best means to prevent a recurrence of the evil.

IV. Mash from Grain and Potatoes with Sulphuric Acid.

We have already seen that some dilute acids are as capable of converting starch into sugar as the diastase of the malt; dilute sulphuric acid is commonly applied for this purpose, though, generally speaking, the process cannot be recommended. It is true that by the use of sulphuric acid a more concentrated mash can be obtained, and a consequent higher yield of alcohol from the mashing space, which is of advantage in countries where the tax is levied on the latter, but even this is scarcely a compensation for the loss of the grains as feed. Leplay first recommended the mode of preparing mash by means of sulphuric acid. The grain to be worked is converted into a fine grist, and the grist soaked in lukewarm water for a few hours, with frequent stirring, to separate as much as possible the starch granules from the bran. The

required quantity of sulphuric acid, diluted with water, is brought to the boiling point in a capacious vessel, best provided with a stirring apparatus. The liquid grist mass is then gradually poured into the boiling acid fluid. In the boiling fluid the formation of paste is not perceptible, but as soon as it cools off somewhat, it thickens in consequence of the formation of paste, returning, however, to its thinly-liquid condition in a few moments, when a fresh portion of grist is added. This is repeated until the last portion of the grist has been poured in, when the boiling is continued until saccharification is as complete as possible. The acid liquid is then drawn off into a vat for neutralization, which is done in exactly the same manner as in starch factories. The neutralized fluid is then cooled off and brought at once into fermentation, or the sulphate of lime (gypsum) which is formed is first allowed to settle, and the supernatant fluid is then drawn off and brought into fermentation.

To prepare mash from potatoes by means of sulphuric acid, the potatoes are first converted into a pulp, which is thrown into a large vessel containing water. The starch cells separate, some settling to the bottom of the vessel, others becoming mixed with the cellular tissue of the pulped potatoes. The brown-colored supernatant fluid, wherein is also contained the albumen of the potatoes, which would, if left, interfere with the action of the sulphuric

acid upon the starch, is first siphoned off and is given as drink to cattle, or is used for the purpose of moistening dry fodder. While this operation is in progress 1.5 to 2 kilogrs. (3.3 to 4.4 lbs.) of strong sulphuric acid diluted with 3 to 4 liters (.792 to 1.05 gallons) of water for every hectoliter (2.83 bushels) of potatoes are heated to the boiling point in another vessel, and the previously washed green potato starch is gradually and in small portions added to the boiling fluid. The boiling is continued until the whole of the starch, as well as all the dextrine, is converted into glucose, the course of the progress of the conversion being ascertained by iodine water, while the insolubility of dextrine in alcohol affords a means of ascertaining whether the conversion of this substance is complete. A sample of the fluid, when agitated with alcohol, should exhibit no milky appearance. After about five hours' boiling, the formation of sugar will be complete. The fluid is then first run into a vessel with double bottoms, one of which is perforated with small holes so as to admit of acting as a strainer to retain cellular tissue, etc., after which the fluid is run into another vessel, and while therein is neutralized by the addition of chalk. The gypsum having settled down, the fluid is again transferred to another vessel. The wash of the sediment having been added, the liquid is ready for fermentation.

VII.

DISTILLATION OF THE VINOUS MASH.

PRIOR to fermentation, the mash is chiefly a solution of glucose, dextrine, proteine substances, and various salts mixed with insoluble grain husks or potato skins. After fermentation, it is a solution of alcohol, fusel oil, acetic acid, carbonic acid, succinic acid, glycerine, and some undecomposed mash-extract, mixed with the above-named insoluble substances and with yeast. Alcohol, carbonic acid, succinic acid, glycerine, and fusel oil are the products of decomposition of the sugar by the fermenting process, while the acetic acid is formed from the alcohol by the action of the air, and yeast is produced at the expense of proteine substances.

For our purposes the constituents of the fermented mash may be divided into volatile and non-volatile constituents, viz:—

Volatile Substances.—Water, alcohol, acetic acid, fusel oil, carbonic acid.

Non-volatile Substances.—Mash extract, especially its salts, yeast, grains, etc.

Water constitutes the greater portion of the volatile substances; alcohol amounts to about 6 or 8 per cent. by weight, and acetic acid, fusel oil, and carbonic acid occur in proportionally very small quantities.

In heating the fermented mash, the carbonic acid escapes first, and then the alcohol, water, acetic acid, and fusel oil evaporate, so that the non-volatile substances can be separated from the volatile constituents. By continuing the heating in an apparatus which allows of the recondensation of the vapors of the alcohol, of the water, acetic acid, and fusel oil, a mixture of these volatile substances is obtained. The carbonic acid, not being recondensed, is lost, but as it is of no consequence for our purpose we leave it out of consideration.

Water boils at 100° C. (212° F.), and alcohol at 78.3° C. (173° F.). Thus it might be thought that, while the boiling point of water is 21.7° C. (39° F.) higher than that of alcohol, it would follow that when a vinous mash is heated to 80° C. (176° F.) only the alcohol would be converted into vapor, the water remaining behind. But this is not the case, for under all circumstances the boiling point of a mixture of alcohol and water is higher than that of pure alcohol alone, and the vapor formed consists of both alcohol and water. The reason is partly due to the affinity of alcohol for water, partly also to the fact that water evaporates at a lower temperature than its boiling point; the former (affinity) retains alcohol and prevents its escape at the proper boiling point (78.3° C., 173° F.) in the shape of vapor. If the mixture of alcohol and water be heated to its boiling point (suppose 90° C., 194° F.), much more alcohol will be converted into vapor,

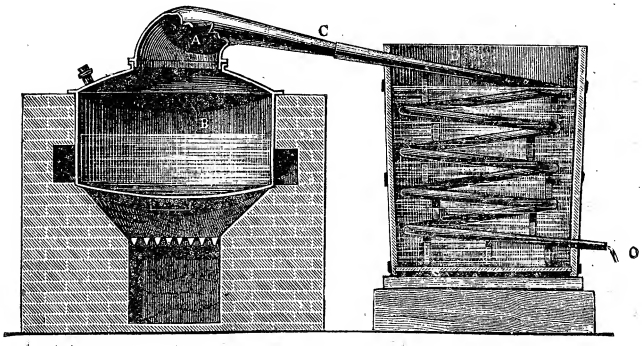
because its boiling point is lower, while of water just so much is evaporated as would be the case were it, when pure, to be heated to this temperature, while simultaneously a current of air is passed through it, because the vapors of alcohol evolved from the mixture act exactly in the same manner as would a current of air carried through the mixture of alcohol and water, the former substance taking up just as much water as will be volatilized at the boiling point of the mixed liquids. As the quantity of vapor evolved from a liquid bears a direct relation to the temperature of that liquid, the quantity of aqueous vapors in the mixture of vapors will increase according to the increase of temperature, until at last, as soon as the boiling point rises to that of water (100° C., 212° F.), no more alcohol will be present in the vapors which are given off. At the commencement of the distillation, the vapor given off contains much alcohol and little water; presently more water comes over, and finally only water. It is therefore quite evident that we cannot by distillation separate alcohol at once from the rest of the volatile constituents of a vinous mash liquor. By interrupting the distillation at the proper time, there is obtained in the distillate all the alcohol contained in the mash along with a certain quantity of water, while the residue of the distillation will not contain even a trace of alcohol. The liquor obtained by the first distillation is generally very weak alcohol, and requires further rec-

tification. The process is to increase the proportion of alcohol. This rectification, which is another process of distillation, may be continued until the alcohol contains only a small quantity of water, which can only be eliminated by the aid of such substances as have a greater affinity for water than the alcohol, which retains the liquid very tenaciously. The first portions of liquid obtained by the distillation of vinous mash are rich in alcohol and are termed fore run or first run, while the last portions of the fluid yet containing alcohol are called after-run. Distillates containing less than 40 per cent. of alcohol are called low wines, and those prepared from them by rectification and containing 40 to 50 per cent. of alcohol, whiskey; while those containing 60 to 95 per cent. of alcohol are termed spirit. A stronger alcohol than 95 per cent. cannot be obtained by means of rectification alone.

A distilling apparatus, as usually employed, consists in its simplest form of four parts, namely, the still, the head or cap of the still, the cooling apparatus, and the receiver. Fig. 14 represents a simple distilling apparatus used at present only in small distilleries. The still, *B*, is generally constructed of sheet-copper, more rarely of iron boiler plates. The shape of the vessel varies, but is generally a somewhat flattened cylinder, provided with a round opening 12 to 14 inches in diameter, fitted with a collar about 1 inch in height, forming the neck upon which the cap or head, *A*, is placed. From the head,

the pipe, *C*, conveys the volatilized alcohol into the serpentine pipe (worm), *D*, placed in the condenser filled with cold water. The recondensed liquid leaves the worm at *o*.

Fig. 14.



These simple stills have the disadvantage that a distillate of the required commercial strength can only be obtained by a repeated process of distillation, this, of course, being a costly affair both as regards consumption of materials, fuel, etc., and loss of time. At the present day distilling apparatuses are generally so arranged that by a kind of dissociation of the mixture of vapors, alcohol of any desired strength can be at once prepared. However much the shape and details of construction of the apparatus may vary, they all agree in this respect, that the mixture of vapors of alcohol on their way from the still to the condenser become continu-

ously richer in alcohol, so that on reaching the cooling apparatus, strong alcohol is the result of the operation. This result can be attained in two ways: 1. By causing the mixture of vapors to pass repeatedly through alcoholic liquids formed by the condensation of the vapors first given off; when afterwards the temperature increases, in consequence of the continued rush of vapors into the liquid, a new process of distillation begins, the vapors generated by it being far richer in alcohol than when the first distillation took place (*principle of rectification*). 2. By so cooling the mixed vapor that the water only is condensed, the alcohol passing on as a vapor (*principle of dephlegmation*).

Most of the recent distilling apparatuses may be considered to consist of the following parts:—

1. The still or vessel in which the fermented mash is placed.

2. Two condensing apparatuses, one of which serves as rectifier, while the other completes the condensation of the products.

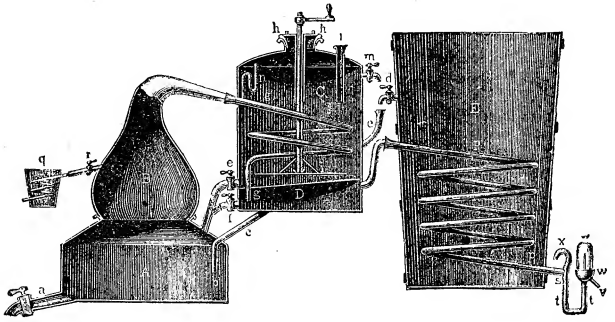
3. A dephlegmator in which the mixed vapor separates, a portion of the water becoming condensed, and a vapor richer in alcohol being carried forward, this latter being carried into the cooling apparatus, while the former flows back into the still.

In the following, we propose to describe a few of the more important recent distilling apparatuses.

Dorn's still, represented in Fig. 15, is an example of an apparatus provided with a rectificator.

A is the still; *B* the helm; *C* the wort-warmer (fore-warmer), with the worm, *g*; *D* the rectificator separated from the wort-warmer by a copper partition; *E* is the condenser, with the worm, *p*. The

Fig. 15.



wort-warmer is provided with a cover, *h h*, fitted with a tube through which passes the shaft of the agitator, *i*. The mash is admitted into the wort-warmer through the pipe, *l*, to a level with the cock, *m*. Any alcoholic vapors forming in the wort-warmer are conducted into the worm, *g*, by the bent pipe, *n*, placed upon it.

The mash is drawn from the wort-warmer into the still by the pipe, *e*, which is provided with a cock. The low wines are drawn from the rectificator into the still through the cock, *f*, and the residue is removed from the still by opening the

cock, *a*. Warm water for rinsing the still, after drawing off the residue, is admitted from the condenser through the pipe, *c b*, by opening the cock, *d*. A small pipe with a stopcock, *r* (so-called test-cock), is inserted in the helm, which pipe is connected with the end of a small worm in the condenser, *g*. This serves to ascertain whether the mash contains any more alcohol.

An apparatus is furnished at the end of the worm, as it issues from the condenser, in order that the flow of liquor may be observed, and its strength noted at the same time. It consists of a tube bent at right angles as at *s t t*, the upper part of which terminates in a curve, *x*, through which the air of the worm is expelled. The arm, *t*, is terminated in a basin holding an inverted glass jar, *W*, in which a hydrometer is placed and floating in the spirit to tell the proper strength. The pipe, *v*, carries off the finished spirit into the tank.

After closing all the cocks with the exception of *m*, distillation is begun by filling the wort-warmer, *C*, with liquor through the pipe, *l*, till it flows out at the stopcock, *m*, after which the cock, *e*, is opened till the still is filled to an overflow pipe, which regulates the amount of liquor to be introduced, but which is not seen in the illustration. The cock, *e*, is then closed and the furnace lighted under *A*, in case distillation is carried on with direct firing, or steam is admitted into the still, after

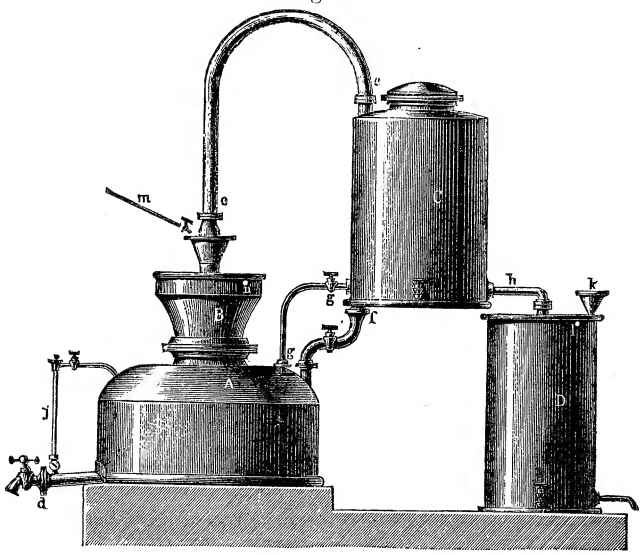
which the wort-warmer is refilled and the cock, *m*, closed. As the alcoholic vapor rises, it is partly condensed in the few coils of worm in the vessel, *C*, the liquid falling down to the rectificator, *D*. As the liquor collects in the bottom part of the vessel, the uncondensed vapor gurgles through it, and further deprives it of aqueous vapor; the uncondensed portion then issues through the connecting pipe to the large worm in the condenser, *E*, where it becomes wholly liquefied; the excess of liquid in the lower part being returned to the still by the pipe, *f*. Distillation is continued until the distillate shows 40 to 35 per cent. Tr. By opening the cock, *r*, and catching the liquid escaping from the small cooling apparatus, *q*, and testing it with an alcoholometer, it is ascertained whether all alcohol has been expelled from the mash. When this is the case, the charge in the still is emptied through the cock, *a*, and water is admitted from the condenser through the pipe, *c*, before the still is entirely empty, to prevent the burning of the fresh supply of mash, which, as soon as the still is emptied, is introduced from the wort-warmer in the same manner as before, the fire being slackened, or steam shut off while this part of the work is going on.

Since the introduction of a better apparatus, Dorn's is seldom used by large distilleries; it is, however, frequently met with in small establishments, and where brandy is rectified.

Egrot's rum apparatus (Fig. 16), is chiefly used

in English and Cuban rum distilleries. It consists of the still, *A*, which is filled two-thirds full; the helm, *B*, which acts as a dephlegmator; the wort-warmer, *C*, provided with a worm, and the condenser, *D*. *d* is

Fig. 16.



the discharge pipe, *j* the overflow pipe of the still. *m* is a water pipe throwing a jet of cold water first into the small upper funnel from which it runs through small holes into a worm in the helm, escaping at *n*. In its course it is brought to 60° C. (140° F.), and hence causes a vigorous dephlegmation of vapors of alcohol and fusel oil in the helm.

The alcoholic vapors pass through *e* into the worm in the wort-warmer, where they experience a second rectification by dephlegmation, the liquid thus formed returning through *g*. The wort-warmer is connected with the still by the pipe, *f*, while *h* connects the worm in the wort-warmer with that in the condenser; *k* is a pipe for cold water, and *l* the overflow-pipe.

The manner of working is the same as with a simple apparatus. A strong cooling of the condenser is essential to prevent loss of rum.

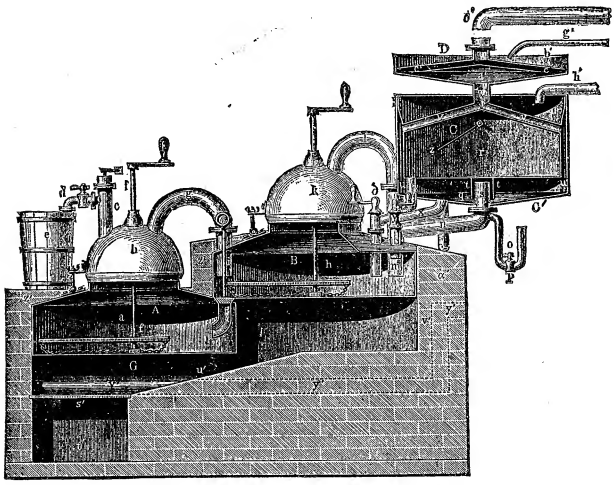
Pistorius first introduced into Germany a distilling apparatus fitted with two stills ingeniously combined with rectificators and dephlegmators. When a distilling apparatus is required which not only extracts all the alcohol from the mash, but also produces the alcohol in a very pure and concentrated state, performing this work with the least possible expenditure of fuel and labor, Pistorius's apparatus (Fig. 17) answers the purpose admirably.

A and *B* represent the two stills. *A* is the main still, which is either placed on a furnace and heated directly by fire, or by means of steam. Heating by steam-pipes instead of direct firing possesses many advantages. The second still, *B*, is placed at a somewhat higher level so that its contents can be discharged into the main still, and, when not heated by steam-pipes, is situated on the flue of the furnace. *C* is the wort-warmer connected

with the rectificator, C'. D is one of three basins placed one above the other.

The arrangement of the apparatus is best explained by the distilling process.

Fig. 17.



The wort-warmer being connected with the mash reservoir, the stills receive their charge of mash always through the wort-warmer, which must, therefore, in the commencement of the operation be filled three times with mash through the pipe, h', the first charge being introduced into the second still through the wide pipe, γ, with the stop-cock, δ, and from this into the main still by means of a connecting pipe having a valve appended,

which will be readily recognized in the drawing, while the second charge is brought into the second still, and the third remains in the wort-warmer. The fire is then lighted and the mash in the main still brought to the boiling point, being frequently stirred by means of the agitator, *f*. The fire is then moderated by partly closing the damper in the chimney in order to prevent the mash from boiling over.

The vapors escaping from the main still pass through the helm, *b*, and the pipe, *g*, into the second still, whose contents in a short time are also raised to ebullition, which takes place at a lower degree in consequence of the quantity of alcohol it receives from the main still. The alcoholic vapor from the second still passes through the helm, *k*, and the pipe *l* (whose lower part, *m*, dips into the mash), into the elbow, *n*, the upper part, *s*, of which passes through the bottom of the rectificator, *C'*, and enters beneath the annular cap, *t t*, fastened to the bottom of the wort-warmer, by which the vapor is forced to descend. The vapor thus conducted into the rectificator being condensed by coming in contact with the exterior cold surface of the rectificator and of the lower part of the wort-warmer, falls to the bottom. After the temperature in the interior of the rectificator has sufficiently risen by the vapor gradually streaming in, the liquid is again brought to ebullition causing rectification.

The vapors which are developed enter the nar-

row space, *u*, between the sides of the wort-warmer and rectificator, and pass through the two pipes, *v v*, which unite in the centre to *w*, into the lowest basin, *D*, where they are forced to spread out by the disk, *c' a' c'*, and are precipitated by the lower surface of the basin which is surrounded by cold air. As they suffer the same action from the upper surface of the basin which is cooled by water, they pass over the disk and enter a second basin similarly arranged, and from this, sometimes a third basin, and pass finally into the worm of the condenser. The bent pipe, *p*, on *n*, is a safety pipe.

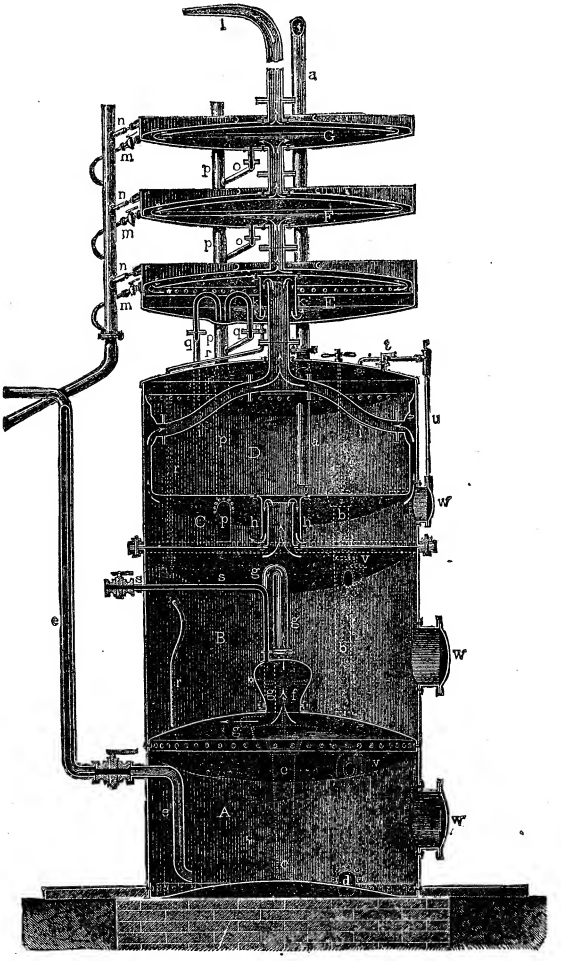
It is obvious that the distillate commences to pass over only at a considerable time after the mash in the main still has been brought to ebullition. The commencement of passing over is recognized when the hand cannot be placed without burning upon the pipe *d'* leading from the upper basin into the cooling pipe. A thin stream of water is then allowed to flow through *g'* upon the basin. Care must be had not to admit too much water at first, as the vapors which first escape are very rich in alcohol and contain less free and latent heat than the succeeding more aqueous ones, and distillation would in consequence be delayed by the unnecessary condensation of the vapor rich in alcohol and sufficiently rectified. To effect a proper regulation of the quantity of water, on which depends the percentage of alcohol of the distillate, the pipes are provided with cocks in convenient places. The

water is generally conducted upon the centre of the basin provided with a rim over which the water pours in all directions. The escape pipe for the heated water, which cannot be seen in the illustration, is on the edge of the basin. The upper basin must be kept cooler than the second, and this cooler than the first, so that the vapors pass constantly into cooler rooms.

When the mash in the main still is exhausted, the fire is slackened by inserting the damper plate into the flue to cut off the draught, and the residue is drawn off. The mash from the second still is then admitted into the main still and that from the mash-warmer through γ, into the second still, and the mash-warmer is charged with fresh mash.

Fig. 18 is a modification of the Pistorius still. Though widely different in form, the principle upon which it is designed is precisely the same. *A* is the main still; *B* the second still; *C* the rectificator with the mash-warmer, *D*; *E* the lower basin, and *F* and *G* the upper basins. *a* is the pipe for filling the mash-warmer from the mash reservoir; *b* a pipe with valve attached to conduct the mash from the mash-warmer into the upper still, *B*; *c* the pipe for admitting the mash from the still, *B*, into the still, *A*; *d*, an aperture for the pipe for drawing off the residue; *e* the steam pipe for the distillation of the still, *A*. The pipe, *g*, on the helmet of the still, *A*, serves to conduct the vapors escaping from this still into the mash in *B*. *h* is the cap of the rectificator

Fig. 18.



C, by which the entering vapors are forced to pass through the fluid collected on the bottom. The pipes, *i i*, serve to conduct the vapors from the rectificator into the basin, *E*. *K* is the cap of the basin, *E*. From this the vapors pass through the basins, *F* and *G*, from which they are finally conducted through the pipe, *l*, into the condenser. The arrows indicate the direction of the vapors. The pipes, *m m m*, serve to withdraw the water from the basins, while *n n n* are discharge pipes for the water flowing upon the basins. *o o* are pipes through which the liquid condensed in the basins, *F* and *G*, pass into the pipe, *p*, and from this either into the rectificator, *C*, or, by closing the cock, *x*, on *p*, through the rising pipe, *q'*, into the basin, *E*. The pipe, *r*, serves to conduct the liquid from *E*, into the rectificator, *C*, while the contents of the latter can be brought through the pipe, *r*, into the still, *B*. *s* is a test pipe through which the vapors of the main still, *A*, are conducted into a small condenser to test the percentage of alcohol. *t* is the safety valve, and *u* the glass gauge of the mash-warmer. *v v* are the safety vales of the stills. *B* and *A* and *w* are manholes.

Siemens's Centrifugal Apparatus.—Siemens has demonstrated that the distillation of the mash is incomplete or very slow with the ordinary introduction of steam. Hence he has contrived an arrangement by which the mash is conducted upon revolving disks, which divide it very finely and

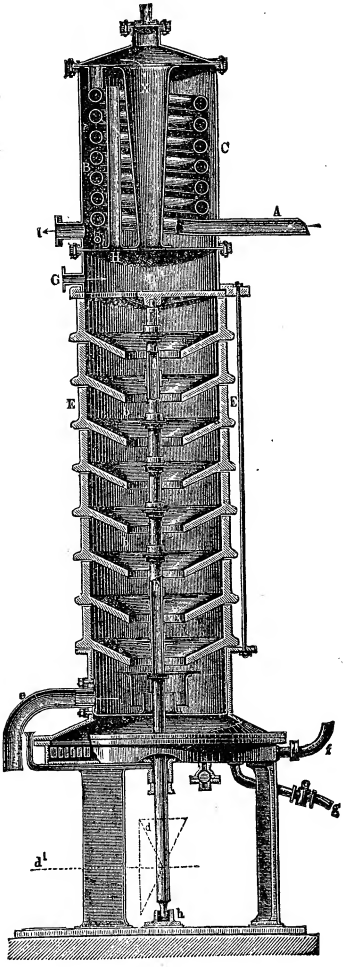
bring it in intimate contact with the introduced steam. The disks revolve in funnel-shaped divisions of a distilling column, which serve to collect the finely divided mash and to conduct it upon the next disk. The column, which answers the purpose of a still, is provided in the centre with an upright shaft carrying the disks. Rotation is effected from below by means of a paddle wheel placed in the lower part of the column and set in motion by the steam before the latter enters the column.

This arrangement, according to the results of experiments made with the apparatus, has proved very effective, and several of the apparatuses have been introduced into Cuba and Rio Janeiro.

The principal parts of the apparatus are shown in section in Fig. 19.

The mash enters at *A* the coil *B*, which is placed in the mash warmer, *C*, passing through it from the bottom to the top. The vapors developing from the mash occupy the external space between *B* and *C*, and, while heating the mash in the coil, are themselves condensed. The part, *C*, of the apparatus may therefore be termed a condensing mash-warmer. The mash passing over at *x* reaches the column through *D*. Through the centre of the (iron) column, *E*, passes the copper-coated shaft, *F F*, which carries the copper disks, *b b b*. The column is formed of separate rings,

Fig. 19.



with funnel shaped bottoms, or of truncated cones, *a a*, held together by suitable bolts or screws.

The steam enters through *f*, and, after setting the paddle wheel in motion, ascends the column and meeting the mash coming down deprives it effectively of its alcoholic vapors. After reaching the mash-warmer it is partly condensed, and passes through *I* into the rectifying parts of the apparatus, which may be of the usual construction.

The shaft, which projects downward, revolves in the step-bearing *h*.

This apparatus has thus far been only used for the distillation of molasses, but there can be no doubt of its availability for other mashes.

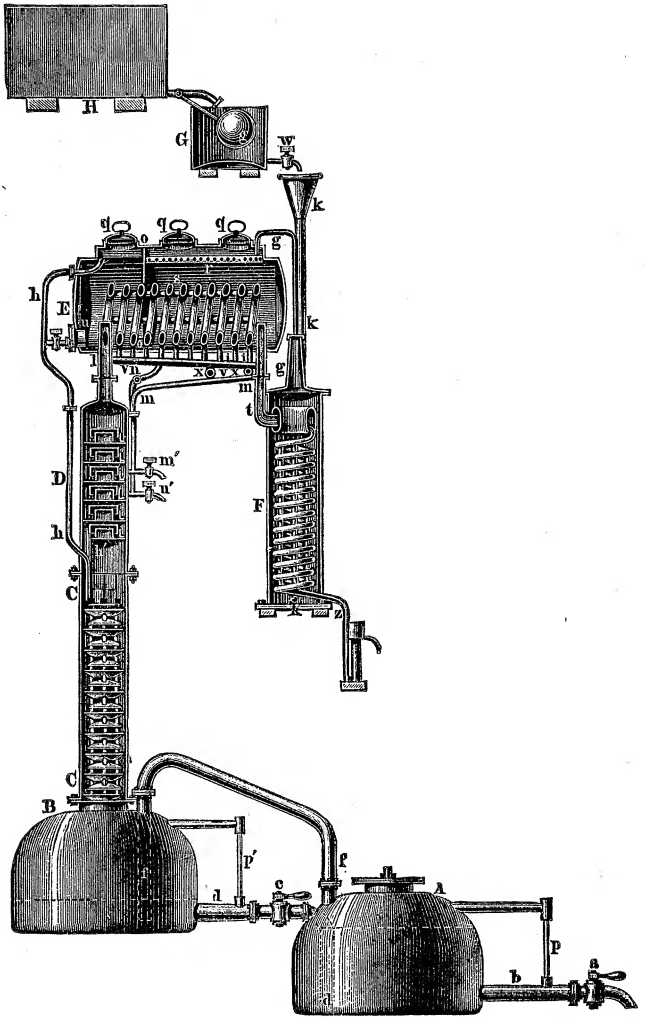
Collier-Blumenthal's Apparatus improved by Derosne.—This is one of the oldest stills employed for continuous distillation, and is much used in France for the distillation of wine, beet juice, and other thin mashes. It is not available for thick mashes.

Fig. 20 is a general view of the apparatus.

A is the main still, and *B* the second still upon which stands the column, *C C D*, the lower part, *C C*, of which is the distilling column, and the upper part, *D*, the rectifying column. *E* is the mash-warmer with a coil. *F* is the copper condenser, with worm. *G* is a small vessel for the fluid to be distilled (wine, etc.). This vessel supplies itself by means of an automatic tap, from the store-vat, *H*.

The still, *A*, is bricked in over a furnace; *b* is a

Fig, 20.



pipe passing through the brickwork, and provided with a stopcock, *a*, for drawing off the residue. The gauge glass, *p*, of the still sits upon this pipe.

The still, *B*, stands at a higher level than *A*, so that its contents can be drawn into the latter through the pipe, *d c d*. It is heated by the hot air escaping from the furnace of the still, *A*. *p* is the gauge-glass of the still, *B*. The pipe, *f f f*, which terminates in a rose, conducts the vapors developing in the still, *A*, into the contents of the still, *B*. Inclosed in the distilling column, *C C*, are nine pairs of copper plates; the lower plate of each pair, which is much larger than the upper, has its concave side turned upward, and the latter its convex side. The plates are fastened to three copper rods so that they can be taken out and replaced as a whole. The concave plates are so large as to almost touch the sides of the column, and are provided in the centre with an aperture. Hence, when the liquid to be distilled flows through the pipe, *h h*, in the uppermost concave plate, it passes through the aperture of this plate and falling upon the succeeding smaller plate, it spreads out upon this, and falling over the rim of this plate passes into the second concave one, and so on, until finally it reaches the still, *B*.

The vapors developing in the still, *B*, pass into the column in an opposite direction to that of the mash, *i. e.*, while the latter falls down in the column, the former ascend it and become laden with

the alcohol of the mash. As the concave plates, as stated, are so large as to nearly touch the sides of the column, the vapors are forced to pass chiefly through the mentioned apertures.

From the column, *C C*, the alcoholic vapors pass into the upper column, *D*, which incloses six condensing basins of essentially the same construction as the plates in the distilling column. The wide pipes of the basins are covered with a cap or a bell, which forces the vapors to pass through the liquid in the basins. Only the lowest basin, as will be seen, has a drip-pipe, through which the liquid flows back into the upper basin of the column, *C*, while the liquid collected in the other basins, runs, after reaching the height of the steam pipe, through this back into the basins situated lower down.

From the uppermost condenser of the column, *D*, the vapors, which are now rich in alcohol, pass into the worm, *s*, of the condenser, *E*, which communicates through the pipe, *t*, with the worm of the refrigerator. To understand the action of the worm, *s*, it is necessary to consider the course the mash has to run. The apparatus requires no cooling water, the mash itself acting as a substitute. By properly opening the tap, *w*, a sufficient quantity of mash is allowed to flow from the reservoir, *G*, which, as previously stated, is supplied by means of an automatic tap, from the store vat, *H*, into the funnel-pipe, *h*, which passes into the refrigerator at *k*. The mash being heated by the worm of the

refrigerator rises, in consequence of the pressure of the liquid in the pipe, *k*, into the pipe, *g g*, which conducts it into the mash-warmer, *E*, where it is heated still more, and finally runs almost boiling hot through the pipe, *h h*, into the distilling column, *C C*. In order to effect the running off of the hottest mash from the mash-warmer, the latter is divided into two divisions by the partition, *o*, which is only provided with an aperture near the bottom. The front division is the smallest, and contains the hottest coils of the worm, while the others lie in the back division. The mash flowing through *r r* into the back division passes through the aperture in the partition into the front division, where it is heated to almost the boiling point by the hot coils of the worm. *q q q* are arm-holes for cleansing the mash-warmer.

From each coil of the worm in *E*, except the first and last, a small pipe passes vertically through the bottom of the mash-warmer. All the pipes enter a collecting pipe lying nearly horizontally and having but a slight fall towards the refrigerating pipe, *t*, into which it passes. From the refrigerating pipe, two vertical pipes, *x x'*, provided with cocks (return pipes) branch off towards the side of the condenser, and enter the pipe, *m m*, which is slightly inclined towards the column, and passing down on the side of the column and bending upwards, enters the third plate from the top. Another pipe, *n*, also provided with a cock,

branches off from the collecting pipe, runs down the column, and, turning upwards, enters the fourth plate, *i. e.*, the one below the third.

The liquid formed by the condensation of the vapor in the worm, passes from each coil through the respective pipe, into the collecting pipe. If the cocks, x and x', and the cock on n, are closed, all the condensed liquid runs into the refrigerating pipe, t. If, on the other hand, all the cocks are open, the condensed liquid passes into the pipes, m m and n, and from these back into the column, while only the vapors remaining uncondensed in the worm, pass through t into the refrigerator; the distillate obtained in this manner being of course the strongest, and that in the first case the weakest, since all the phlegm (water of distillation) reaches the refrigerator. By closing or opening the separate cocks, x' x and n, the distiller can at pleasure obtain a strong or weak distillate.

The manner of carrying on the work with this apparatus is as follows: The still, A, is first filled three-fourths full with the liquid to be distilled, and then the still, B, about one-fifth full. The fire is then applied under A, the refrigerator and mash-warmer being also filled in the mean while with the liquid to be distilled by opening the cock, w, on G, but the flow is interrupted by closing the cock, w, as soon as the liquid begins to run into column and fall into the still, B, which is recognized by the gauge-pipe, p'.

When the liquid in the still, A, is heated to the

boiling point, the alcoholic vapors formed are conducted through the pipe, *f*, to the bottom of the still, *B*; the vapor in passing through *B* condenses in part, at the same time heating the contents. The vapors then pass through the column, *C* and *D*, and enter the worm of the mash-warmer, where they are condensed in consequence of the contents of the mash-warmer being cold in the commencement of the operation. The cocks, *n x x'*, are left open to allow the condensed liquid to run back into the column, *D*.

In the same degree as the contents of the mash-warmer become heated, a more incomplete condensation of the vapors takes place, and the distillate commences to run off from the refrigerating pipe at *Z*, the strength of the distillate being determined, as previously stated, by opening or closing the cocks, *m x x'*. The heated liquid in the mash-warmer is now allowed to pass through the pipe, *h*, into the column, *C*, at first in a weak stream which is gradually increased, the operation being controlled by the cock, *w*. After distillation has been carried on some time and the contents of the still, *A*, are found free from alcohol, the residue is drawn off through the cock, *a*, and the still refilled from the still, *B*, the contents of which have of course much increased by the liquid coming from the columns. Thus the operation is continued by drawing off from time to time the residue from *A*,

and refilling it, which makes the distillation a continuous one.

To obtain brandy as the result of distillation, the cocks, n x x', are kept closed; while for the weak spirit, n is left open; for stronger spirit, x, and for the strongest distillate, all three cocks.

Cellier-Blumenthal's Apparatus for Thick Mashes, modified by Cail.

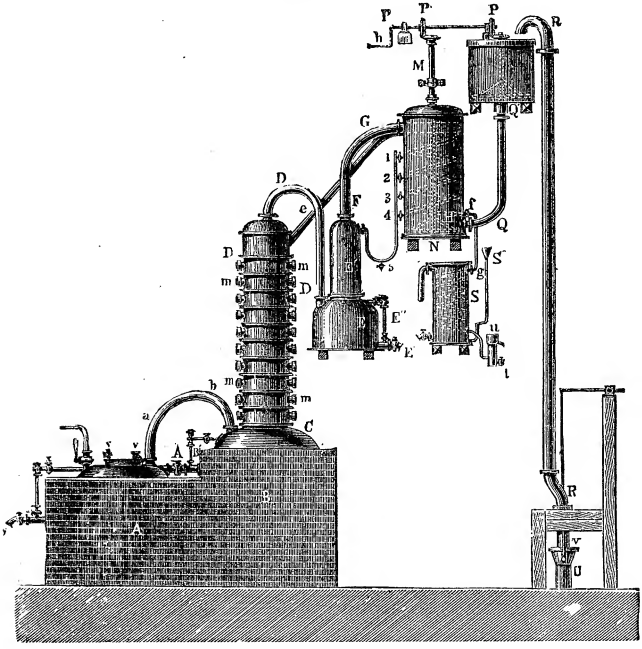
This apparatus (Fig. 21) is provided with two stills, A and B, placed one above the other, which are heated either by a furnace or by steam introduced through the pipe, z. y is the discharge cock; x, the gauge-pipe of the main still; v, a safety-valve, and v', a test-cock.

The vapors are conducted through the pipe, a b, into the still, B, from whence they ascend the column, C D, which contains ten divisions consisting of plates with pipes and caps, and provided on each side with large apertures, m m, for the purpose of cleaning them. The vapors after repeated condensation pass through D' D'' into the vessel, E. The low wine condensed in the worm runs back into E and E', where it is rectified by evaporation. In H is the principal rectificator in the form of a condensing worm, whose coils conduct the return pipes, which can be used at pleasure, to F. S is the refrigerator; the distillate is discharged at u.

The thick mash is forced through the pump, R, into R', where it is kept in constant motion by an

agitator moved by *h P P''*, and flows through *Q* into the condenser, *G H*, which serves at the same time as mash-warmer, where another agitator set in motion by the shaft, *M N*, prevents the settling

Fig. 21.



down of any solid parts. The hot mash runs from the upper part at *G* through *c* into the upper part of the column, *D C*, over the intermediate plates into the second still, *B*, and so on. The apparatus works continuously. The still, *A*, is emptied, accord-

ing to Payen, every hour, and an apparatus producing 20 hectoliters (528 gallons) of 95 per cent. alcohol requires a steam boiler of 25 square meters (269.1 square feet) of heating surface.

Caffey's apparatus, which is used in nearly all the large English distilleries producing only spirit, differs in its construction from all other stills. The apparatus consists of three parts, viz., the column *A* called the analyzer, the column, *B*, called the rectifier, and the condenser, *C*. The column, *A*, consists of a number of chambers, *a a a*, formed by the interposition of copper diaphragms which are perforated with numerous holes and furnished with valves opening upwards. To each of them is also attached a dropping pipe, *b*, by which the liquor flows from plate to plate; the upper end of each pipe projects about $1\frac{1}{2}$ inches above the plate in which it is inserted, so that at all times during the distillation, a stratum of wash of that depth remains upon each diaphragm. The lower end of each pipe dips into a shallow pan on the diaphragm beneath, thus forming a steam trap, by which the escape of vapor through the pipe is prevented. The pipes are inserted at alternate ends of the diaphragms as shown in the figure; *d* is the steam pipe; *e* the discharge pipe for the swill, which collects in the reservoir, *f*. The alcoholic vapors developed by the current of ascending steam and descending liquid pass through into the column, *B*, which is called the rectifier,

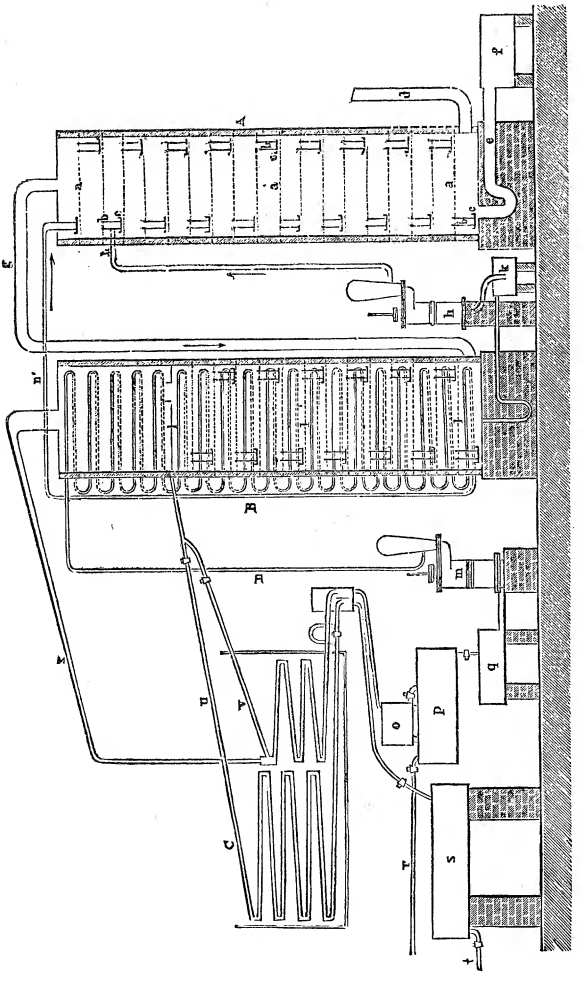


Fig. 22.

and the low wine formed is pumped by the pump, *h*, from *K* into *A*.

The column *B* is divided into chambers by interposed copper plates in a manner similar to that just described. The lower chambers, *l l l*, constitute the rectifier, and its diaphragms are perforated and furnished with valves and dropping pipes precisely similar to those of the analyzer. The upper chambers form the finished spirit condenser, and are separated from the lower chambers by a copper diaphragm, *l'*, without perforations, but having a large opening for the passage of alcoholic vapors, and a dropping pipe.

The pump, *m*, is worked continuously during the operation so as to supply the apparatus with a regular stream of wash. It is so constructed as to be capable of furnishing somewhat more than is necessary, and there is a pipe with stopcock by which part of what is pumped up may be allowed to run back, and the supply sent into the apparatus regulated.

The low wine condensed in the lower part of *B*, enters the analyzer, *A*, at *h*, while the hot spirit condensed in the upper part collects upon the diaphragm, *l'*, and passes through *v*, or *u*, according to the position of the respective cocks, into one of the condensing worms in *C*.

In every chamber, both of the finished spirit condenser and of the rectifier, is a set of zigzag pipes, each of which is connected with the other by

bends, thus forming a continuous pipe leading from the mash pump, *m*, to the bottom of the rectifier, whence it finally passes out, and rising up enters the top chamber of the analyzer, where it discharges itself.

When commencing an operation, the wash-pump is set in motion to charge all the zigzag pipes until the wash passes over into the analyzer. The pump is then stopped and steam let into the bottom of the apparatus at *d*. The steam passes up into the analyzer whence it descends to the bottom of the rectifier. It then rises through the chambers, *l l*, enveloping the zigzag pipes, and rapidly heating the wash contained in them. When the attendant perceives by feeling the bends of the pipes that the wash has been heated in several layers of these pipes, he again sets the pump to work, and the wash, now nearly boiling hot, and always in rapid motion, flows from the pipe, *h*, at *b*, and passes down from chamber to chamber through the dropping pipes. It may here be observed that no portion of the wash passes through the small holes perforated in the diaphragms which separate the chambers. These holes are regulated, both in number and size, so as to be not more than sufficient to afford a passage for the vapors upwards, when under some pressure. The holes, therefore, afford no outlet for the liquor, which can only find its way down in the zigzag course from chamber to chamber. It is therefore obvious that the wash, as

it passes down, is spread into as many strata as there are diaphragms, and is thus exposed to the most searching action of the steam constantly blowing up through it. As it falls from chamber to chamber, its alcohol is volatilized by the steam passing upwards, and by the time the wash has reached the reservoir, *f*, no trace of the spirit remains.

The course of the wash being understood, that of the steam requires very little description. The steam passes first through the layers of wash on the diaphragms of the analyzer. In its course it abstracts alcohol from these layers of wash, depositing water in its place. After traversing the whole of the analyzer, the vapor, now containing much alcohol, passes into the bottom of the rectifier, and, as it ascends, it envelops the pipes and heats the wash contained in them, simultaneously parting with its more watery portion, which is condensed, and falls in the state of ebullition on the several diaphragms of the rectifier. By the time the vapor reaches the passage in the diaphragm, *l'*, it is nearly pure alcohol; and as it is condensed by the wash in the pipes and falls on the diaphragm, it is conducted through *u*, or *v*, to a refrigerator. At the top of the spirit condenser is a large pipe which serves as a vent for the uncondensable gas disengaged in the process, and this pipe also communicates with the refrigerator, so that, should alcoholic vapor at any time pass out of the apparatus, no loss

is sustained beyond the waste of fuel caused by condensing it by the water of the refrigerator instead of the wash of the condenser.

The liquor formed on the several diaphragms of the rectifier descends to the bottom in the same manner as the wash falls from chamber to chamber in the analyzer, but as it still contains alcohol, it is conveyed by a pipe to the pump, *m*, by which it is raised up with the wash to be again distilled.

The water for supplying the boiler passes through a long coil of pipe immersed in the boiling-hot spent wash, by which means it is raised to a high temperature before it reaches the boiler.

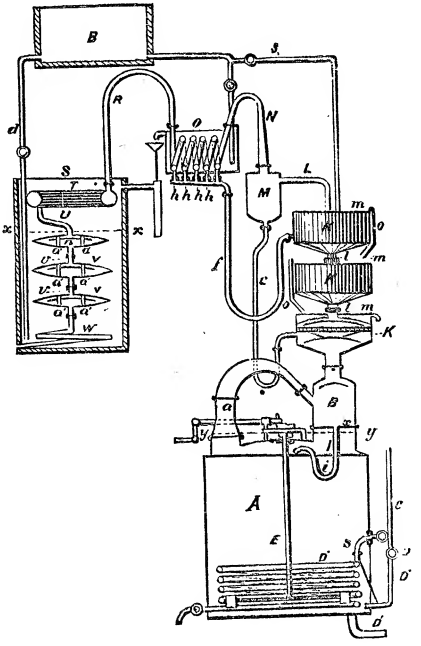
The vapor passing through this apparatus is condensed by the wash and not by water, and no heat is wasted.

The apparatus is chiefly intended for distilling on a large scale, and on account of the narrowness of the pipes through which the wash passes, is only available for thin mashes (worts).

New American Still.—The alcohol still represented in Fig. 23 is an American invention, and consists chiefly in a novel construction of the vapor condensers, and means for returning to the boiler or heating tank, the heavy products of distillation which become separated from the vapor in its passage through the condensers. The annexed drawing is a vertical section of a still embodying this improvement. *A* is the still, the heat being supplied by a coil-pipe, *B*, and a steam-pipe, *C*, pro-

vided with a stopcock, D, which serves to control the influx of steam. A branch-pipe, C'', is extended from the steam-pipe, C, and enters the tank at or near the bottom thereof. By means of a stop-

Fig. 23.



cock, D', applied to the pipe, C'', the steam can be prevented from passing through said pipe, until it becomes necessary to admit steam at the bottom of the tank for the purpose of assisting the coil, B, to

heat the liquid spirits, which assistance is especially required when the liquid is low in the tank. A perforated cap, C', is applied to the discharge end of the pipe, C'', for the purpose of diffusing the steam issuing from said pipe. F represents the rotary agitator arranged in the tank for the purpose of stirring the substance under treatment, and also for assisting in cleaning the tank, a pipe, E, being connected to the bottom of the tank for the discharge of the rinsing water.

To the top of the tank, A, is connected a capacious vapor-duct, G, which rises a certain height, and then deflects downward to a dome, H, built upon the top of the tank. This pipe or duct, G, conducts the vapor, or products of distillation, from the tank to the dome. The foam, which frequently rises in the tank, A, during the process of distillation, is prevented from following the vapor in its aforesaid passage by the intermediate elevated portion of the duct, G, thus obviating the liability of clogging the return pipe, I, hereinafter described. The dome, H, is deprived of a direct communication with the tank, A, by a diaphragm extended across the base of the dome. An indirect communication, however, is formed by a pipe, I, pendent from the diaphragm, r, and terminating inside of the tank in proximity to the crown-sheet thereof; a downward deflection of the intermediate portion of the pipe, I, forming a trap, i, which prevents the escape of vapor from the tank through the said

pipe; the function of the pipe, *I*, being to return to the tank the heavy products of distillation condensed into the condensers, *K K*, which are superimposed, and communicate with the top of the dome, *H*. Each of the condensing chambers, *K*, is provided on its top with a water receptacle, *m*, having an overflow-pipe, *o*, by which the water is conducted successively from one chamber to the other, the water being conducted to the uppermost condensing chamber, *K*, from an elevated reservoir, *b*, by a pipe, *s*, provided with a cock, *t*, for controlling the flow of water.

From the top of the series of condensing chambers, *K*, is extended a vapor duct, *L*, which intersects a chamber, *M*, at or near the top thereof. From the bottom of this chamber to one of the condensers, *K*, is extended a pipe, *e*, for the purpose of conveying to the latter such portion of the vapor as may become condensed and precipitated in the chamber, *M*; the pipe, *e*, being bent to form a trap, which prevents the vapor from ascending from the condenser, *K*, through the said pipe.

From the top of the chamber, *M*, rises a pipe, *N*, which, by a downward deflection, communicates with a worm, *P*, disposed with its axis horizontal through a vat, *O*, which is filled with cold water by a pipe, *c*, leading from the water tank, *b*. An overflow, *g*, connected with the vat, maintains the water at a uniform height.

The bottom of each of the successive coils of the

worm, *P*, is tapped by a pendent pipe, *h*, which draws therefrom the liquor produced by the condensation of the heavier particles of the vapor circulating through the worm.

A pipe, *f*, connected to the respective pipes, *h h*, and extended to one of the condensing-chambers, *K*, serves to convey to the latter the aforesaid liquid, the pipe being bent in the usual way, to form an intermediate trap.

To the end of the worm, *P*, is connected a vapor-duct, *R*, which communicates with an annular pipe, *T*, arranged horizontally on the upper part of a tank, *S*, which is filled with water by a pipe, *d*, extended from the reservoir, *b*.

Underneath the pipe, *T*, are arranged a series of flat chambers, *V V*, extended nearly across the tank, and placed one below the other. The respective chambers are constructed of two concavo-convex plates, placed with their concave side facing each other and united at their edges. The top of the upper chamber, *V*, is connected with the annular pipe, *T*, by a pipe, *U*, and each of the chambers is connected with its subjacent chamber by a central pipe, *U*. The lowermost chamber communicates at the centre of its bottom with a coil-pipe, *W*, which has its discharge end extended through the side of the tank for the delivery of the distilled spirit. Each of the chambers, *V*, is provided internally with a diaphragm, preferably of cancavo-convex form, and placed with its convex

side upward, which diaphragms deflect and retard the flow of the vapor, and bring the same more intimately in contact with the shell of the chamber cooled by the surrounding water. By means of the flues, *a a*, extended vertically through the chambers, *V*, and open at both ends, the water is caused to circulate through the chambers, and further subject the vapor to the cooling influence of the water.

What is claimed in this invention is the improved still-condenser consisting of the tank, *S*, annular pipe, *T*, pipe, *U*, chambers, *V V*, formed of a convex top plate and a concave bottom plate united at their edges, a convex diaphragm, *n*, inside of said chambers, flues *a a*, extended vertically through the same, pipes *l l*, connecting the chambers, and the coil *W*, or other outlet pipe, all as shown and set forth.

VIII.

RECTIFICATION AND PURIFICATION OF SPIRIT.

ALL spirituous liquors are identical when the extraneous bodies from which such liquors are obtained have been removed, with the exception that a variable amount of water is present in them. They are all more or less concentrated solutions of

alcohol. Thus, the alcohol from wine, rum, malt, potatoes, carrots, beets, grasses, and various other sources, is the same in quality, provided all the solid and liquid impurities be removed. The manufacturer of whiskey, or of any of the other alcoholic liquors, rarely purifies the products, but disposes of them to the rectifying distiller, whose business it is to remove those contaminations which make the liquor disagreeable or injurious. The chief object of the distiller in rectifying spirits is the removal of the volatile oils, known by the general term of *fusel oil*, in order to procure a pure alcohol from which, by the aid of other ingredients, he can fabricate liquors imitating those more costly products which are formed naturally, such as the better varieties of brandy, gin, and all the other kinds of liquors and cordials which are in daily request as favorite beverages.

For the fabrication and purchase of spirit free from fusel oil, it is of the greatest importance to be able to determine accurately the presence or absence of fusel oil. Unfortunately no chemical means have as yet been discovered, and we are forced to rely entirely on taste and odor. All methods of detecting fusel oil in alcohol are based upon it being less volatile than alcohol. Rub the alcohol to be tested between the hands and allow it to evaporate, when the characteristic smell of fusel oil will be perceived. This method, though in general use, is not reliable, since a peculiar odor is frequently observed, even if

the alcohol is free from fusel oil, by the alcohol dissolving oil from the skin.

A better plan is to rinse out a glass with alcohol and allow it to stand until the alcohol is evaporated, repeating the process several times; the remaining phlegm shows the characteristic odor of fusel oil.

Vogel finds that alcohol to which a solution of nitrate of silver has been added, when placed in the sunshine, remains perfectly clear and bright, whereas, if it contains fusel oil, it becomes very strongly reddened. Göbel states that the origin of any alcohol can be ascertained by the following means, even when no particular odor can be detected by ordinary examination: A solution of 1 part of potassium hydrate in a small quantity of water is added to 100 parts of the brandy or spirit to be examined; after agitation the whole is reduced by slow evaporation to 15 parts. An equal volume of dilute sulphuric acid is then added and the mixture well shaken. In the case of potato spirit the vapor evolved has a very disgusting odor, and produces, when inhaled, spasmodic contraction of the throat, headache, and giddiness. In the case of malt spirit the odor resembles that of sour dough, and produces a similar though less powerful physiological action. Rum, arrack, brandy, etc., have, when treated in this manner, each their characteristic and perfectly different odor.

Ulex describes a method arranged for special purposes of determining fusel oil, making at the

same time some statements about certain peculiarities of fusel oils from different raw materials. In England fusel oil is a commercial article and can only be imported free of duty when it contains less than 15 per cent. of proof spirit of 0.920 specific gravity. The manner of testing the fusel oil is as follows: Shake the fusel oil with an equal volume of water and allow the mixture to stand quietly 12 hours, when there will be an upper layer of fusel oil and a lower one of aqueous spirit. By testing the latter with the alcoholometer the percentage of proof spirit is found. But the supposition upon which this determination is based—that fusel oil yields nothing to water—is not true, since the varieties of alcohol, of which the fusel oil consists, possess, according to their origin, a different degree of solubility, amyl alcohol alone being entirely insoluble. Now, as the different alcohols* found in fusel oils boil at different temperatures, varying proportions of fusel oils derived from the different raw materials pass over in distilling at determined temperatures.

Ulex, for instance, found that

	Beet. Fusel oil. p.c. by vol.	Potato. Fusel oil. p.c. by vol.	Grain. Fusel oil. p.c. by vol.
At 80° to 100° C. (176° to 212° F.)	13	13	31
" 100 to 130 C. (212 to 266 F.)	53	30	26
Over 130 C. (266 F.)	34	57	43

* Ordinary anhydrous alcohol boils at 78.3° C. (173° F.), propyl alcohol at 97° C. (206.6° F.), butyl alcohol at 109° C. (228.2° F.), and amyl alcohol at 132° C. (269.6° F.)

pass over. The product at between 80° to 100° C. (176° to 212° F.) was chiefly propyl alcohol, at between 100° to 130° C. (212° to 266° F.) butyl and amyl alcohol, and at over 130° C. (266° F.) amyl alcohol. This shows that beet fusel oil consists only of one-third of alcohol insoluble in water, and that spirit of wine constitutes only the smallest portion of the other constituents soluble in water. Hence the foregoing method of determination can only give inaccurate results, and Ulex recommends the separation of the spirit of wine by uninterrupted distillation, according to which the *determination of spirit of wine in fusel oil* is effected as follows: From 100 cubic centimeters (61.02 cub. inch.) distil off 5 cubic centimeters (0.305 c. inch), shake the distillate with an equal quantity of saturated solution of common salt, and allow the mixture to rest. If one-half or more of the mixture of fusel oil separates, the fusel oil contains less than 15 per cent. proof spirit, while, if less than one-half of the mixture of fusel oil separates, more than 15 per cent. of proof spirit is contained in the fusel oil. In the last case the spirit is determined by shaking the fusel oil with an equal quantity of saturated solution of common salt, less propyl and butyl alcohol being dissolved by this than by pure water, allowing the solution of common salt to separate, and distilling off the spirit.

Rectification and Purification by Distillation.—Experience has shown that by rectifying the spirit

until it contains more than 92 per cent. Tr., the fusel oil is so far removed as to make it impossible to detect the derivation of the alcohol. Hence rectification to the mentioned degree is the simplest means of purifying spirit containing fusel oil.

The apparatuses used for the purpose are generally those in which the still is connected with rectifying arrangements. They vary only in the difference and number of the arrangements used.

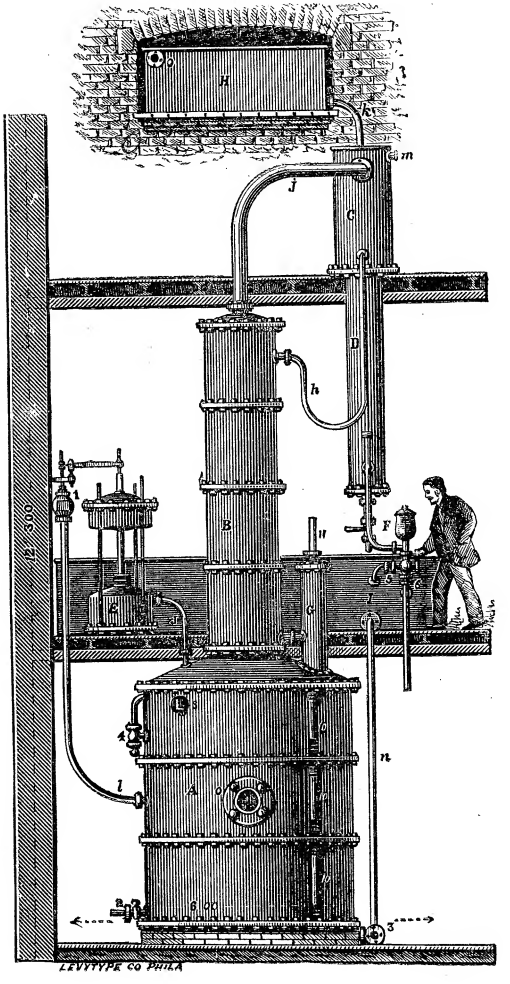
Direct heating is, on account of danger from fire, not permissible, and distillation by steam directly introduced into the still unsuitable, since this would effect a dilution of the alcoholic liquid to be rectified. Hence the still is provided with a steam coil, and, in case it is very large, with two, placed one above the other.

In redistilling, the first portion which comes over has washed out the apparatus, and contains some very volatile bodies; this is called the *foreshot* or *forerun*, and is caught in a separate vessel. As the percentage of alcohol of the liquid in the still decreases constantly during distillation, and hence the escaping vapors become poorer in alcohol and richer in water, it would be very expensive to allow the distillate to run at a high grade to the end of distillation; different products are therefore drawn off in rectifying spirit. After the foreshot comes the purest spirit of about 93 per cent. Tr., then follows spirit of a poorer quality of about 90 per cent. Tr., and then spirit of a bad taste in

which fusel oil is perceptible. The foreshot and the spirit of 90 per cent. Tr., are either sold as ordinary rectified spirit, or are again rectified. The aftershot or afterrun is collected and rectified by itself, the result being different products not entirely free from fusel oil.

Fig. 23 represents a still constructed by Savalle which is much used in France for the rectification of high wine or raw spirit. If the latter is used it is reduced to half its strength by the addition of water. The high wine is brought into the lower copper *A*, where it is heated by means of direct steam, which is passed into the same by means of a perforated worm, or else it is heated by indirect steam, by means of a steam coil. The vapors leave the upper copper and enter the rectification column, *B*. From this they pass through *g*, into the condenser, *C*, from which the condensed liquid flows back to the rectification column, through the pipe, *h*, while the vapors enter into the cooler, *D*. The distilled spirit then passes through the chamber, *F*, containing the alcoholometer, whence it flows to the storage tanks. The apparatus is fed with raw spirit from the reservoir, *J*, to which the waste products of the rectification return. The steam cupola, *G*, is calculated to facilitate the separation of the fusel oil towards the end of the operation. *F* is a pressure regulator for steam, and *H* is a water tank.

Fig. 24.



Rectification by Chemical Agents.—The number of means proposed and sometimes used for freeing spirit from fusel oil is very large, and how much they differ as regards their chemical nature, may be seen from an enumeration of the most remarkable ones. They are: coal, especially wood charcoal, soap, oil and fatty substances, soda, lime, sulphuric acid, nitric acid, chloride of lime, permanganate of potash.

Coal, soap, and oil are supposed to effect a real removal of the fusel oil, by absorbing it, while the purpose of the other agents is either to destroy the fusel oil by oxidation, or by the action of chlorine, or the masking of the oil and its conversion into less disagreeable compounds. When the spirit containing fusel oil is rectified over chloride of lime, permanganate of potash, etc., valerianate of fusel-ether is formed; but since the action of these reagents is not limited to the amylic alcohol, but extends to the ethylic, it is very difficult to adjust the quantity of these reagents so that only the amylic alcohol be acted upon. If the spirits from which the fusel oil is to be removed are treated with a mixture of sulphuric acid and vinegar, there is formed, besides acetic ether, acetate of amyl of a pleasant fruity flavor. Hydrochloric and nitric acids act in a somewhat similar manner.

Caustic potassa—under the name of gray salts—or soda, is added to unite with the oil; pearl ash—white salts—is added with the view of combining

with the water, as well as of taking up the fatty or oily impurities. The alkali combines with the oil, giving a soap which remains in the still, while the spirit passes off divested of its impurities. It has been ascertained that when carbonated alkali is used, the distillate contains a sufficient amount of the salt to affect reddened litmus and turmeric; hence this method cannot always be followed.

The most approved method of removing fusel oil is by means of well-burnt charcoal (vegetable charcoal, charred peat, boneblack), which when brought into contact with the crude spirit absorbs the fusel oil mechanically. By the aid of charcoal, spirits are purified either in the state of vapor, or by digestion with the charcoal, and filtration at the ordinary temperature of the air; rectification at boiling temperature over charcoal is altogether unsuitable, owing to the fact that the fusel oil absorbed by the charcoal is again readily dissolved at that temperature. As charcoal attracts moisture from the air and absorbs gases and vapors, losing thereby its absorbing power for other substances, it is necessary to heat it thoroughly before use and employ it as soon as possible. For rectifying purposes it is granulated and passed through a sieve to remove adhering dust. Charcoal acts the more vigorously in absorbing fusel oil from alcoholic liquids, the less their percentage of alcohol. By treating charcoal, which has absorbed fusel oil from weak spirit, with strong alcohol free from fusel oil,

it yields fusel oil to the latter. Hence it follows that strong spirit must be diluted before treating with charcoal; it is generally reduced to about 60 per cent. Tr. by adding water.

Since charcoal which has absorbed fusel oil from spirit at an ordinary temperature yields up a portion of the fusel oil, when distilled with alcohol, the distillate being the more empyreumatic the weaker it is, and yields up all the fusel oil when heated more strongly, for instance, in superheated steam, it follows that an ordinary temperature is best for freeing spirit from fusel oil by means of charcoal, and that the latter can be revivified by strong heating.

The oldest method of using charcoal is to bring it into direct contact with the spirit for 48 hours, and then draw off the spirit. As the charcoal retains a considerable quantity of spirit, it is collected in a barrel, some water is added and the alcohol distilled off. As the charcoal cannot be reused for rectifying purposes, this method is unsuitable for large establishments.

The method most in use at the present time is to filter the spirit through charcoal. The charcoal is distributed through a number of casks placed so that the spirit can run evenly through the charcoal and other material. In purifying raw whiskey and water care should be taken to properly mix them, as otherwise the water would pass through first, from the fact of the high wines containing such a quantity of oil as to render them much

lighter than the water, so that, unless thoroughly mixed, they would remain on top.

Any number of casks may be used; each one must have a double bottom, the false one being perforated with conical or round holes about one-half inch in diameter, and placed a few inches above the true. Upon this perforated bottom, a layer of clean chopped straw or cleanly carded cotton, or a woollen blanket is laid, and upon this a stratum of clean gravel the size of large peas; on the gravel place 6 inches of coal, then one-half peck of barley malt, then fill up within one and a half feet of the top with coal; then a woollen blanket covered with another layer of gravel; then fill up within eight inches of the top with coal. The rectifier may thus have any number of casks, the contents of all passing by a tin tube furnished with funnels into one common receiver.

The better plan is to have two series of casks, one above the other, a mixer placed over the upper series of casks, the raw spirit passing slowly by means of a faucet and pipes into the upper series of casks; passing from the upper series through faucets into the lower series and through this into a common receiver; the whole to be so regulated as to run slowly and evenly through the rectifiers, passing into the receiver in the same volume as out of the mixer; by so doing the coal remains good for a long time, saving both trouble and expense.

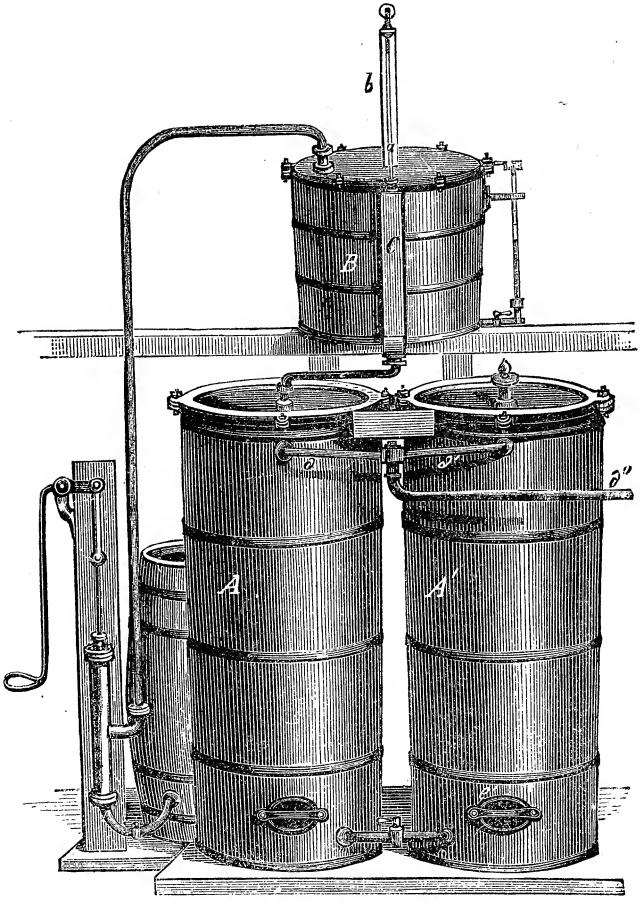
When two series of casks or rectifiers are used, the upper rectifiers may be filled entirely with coal

(after having placed a woollen blanket over the perforated bottom, and a layer of pebbles or gravel) to within ten inches of the top. All the casks are to be closely covered, thereby preventing evaporation. The coal from the top of the lower rectifiers may be removed to the depth of eight inches every six months, and the top of the upper rectifiers once every three months, and replaced by fresh coal, the upper rectifiers requiring more frequent renewals, owing to the larger accumulation of impurities.

Always use the best coal the market affords. When spirits are very crude or impure, it has been found necessary to pass them through six or eight successive series of rectifiers before they were deprived of their rank flavor.

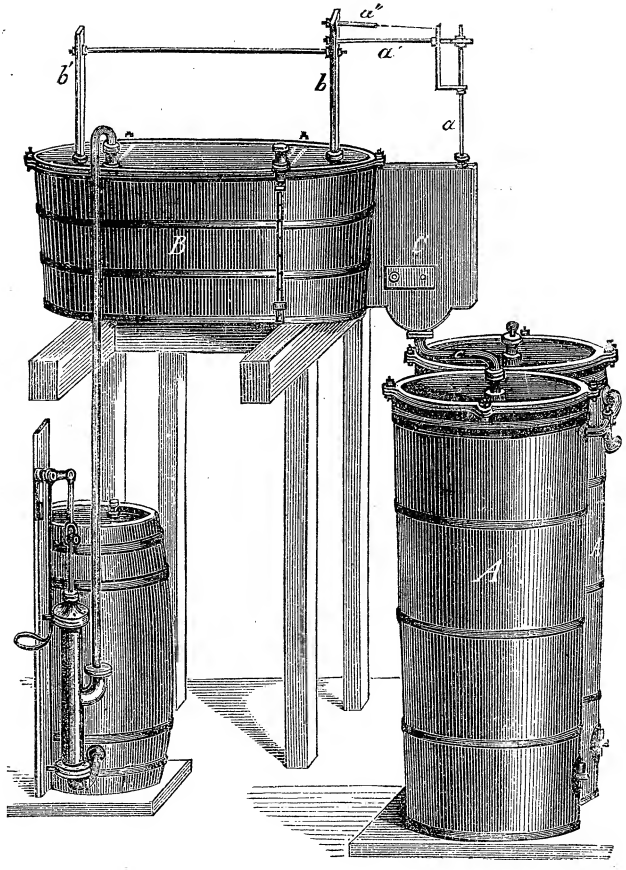
In the accompanying illustrations (Figs. 25, 26, and 27), we give a representation of Blumenthal's apparatus for freeing spirit from fusel oil. It consists of two cylindrical vessels, *A A'*, communicating with each other, the reservoir, *B*, and the box, *C*. The latter contains a regulator which is connected by *a a' a''* with a contrivance in the reservoir. The pipe, *c*, connects the regulating box, *C*, with the spaces in the vessels, *A A*. It conducts the spirit to be purified into a contrivance, which carries it, divided into a fine stream, to the charcoal. *d d* conducts the purified spirit to the receiver. The exhausted coal is removed through the apertures *e e'*. The vessels *A A'* are constructed of wood or sheet-iron.

Fig. 25.



The apparatus can be constructed on a large or small scale, so as to be adapted to every distillery.

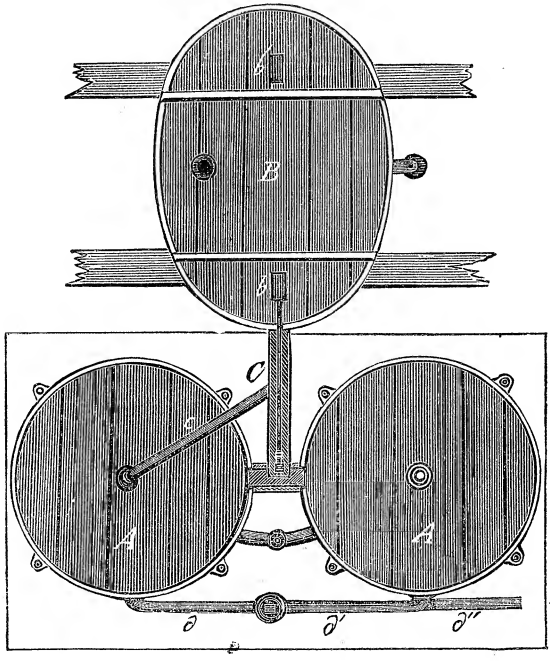
Fig. 26.



Another advantage is that the capacity can be limited, or increased according to desire, so that a

medium-sized apparatus will yield 3000 quarts in 24 hours, or, according to circumstances, only 100 quarts.

Fig. 27.



According to another method of using charcoal for removing fusel oil, the spirit, in the form of vapor, is conducted through a copper cylinder, fitted at top and bottom with a perforated plate or disk; this cylinder is filled with granulated charcoal, and connected with the distilling apparatus

between the dephlegmator and rectificator in such a manner that the vapors pass through the charcoal. To 100 liters (26.4 gallons) of spirit 3 to 5 liters (6.33 to 10.56 pints) of granulated charcoal are generally required. Falkmann's apparatus consists of a helm-shaped vessel, in which four perforated diaphragms are placed; upon each diaphragm comes a layer of charcoal surmounted with a cover. The apparatus is closed with a hollow cover containing a layer of charcoal. The vessel is surrounded by a cooling apparatus, in order to regulate the temperature of the layers of charcoal.

A patent for the purification of spirit has been allowed to J. E. Berlien in Germany. The object of this new method is to effect the purification of raw spirit in a more simple and more efficacious manner than is possible with those in general use. The process consists in adding to the raw spirits nitrate of silver in the proportion of 20 to 50 grammes (0.705 to 1.76 oz.) to 10,000 liters (2641.25 gallons) of raw spirit. For practical use, it is best to prepare a solution of 10 parts of nitrate of silver and 100 parts of water. After adding the required solution of nitrate of silver, the raw spirit is converted into spirit of high degree in the usual distilling apparatus. The spirit refined in this manner is odorless to a degree not reached by any other means.

Kletzinsky has highly recommended soap as a means of removing fusel oil. He found that a

solution of soap, prepared with spirit containing fusel oil, which was to be used for the manufacture of transparent soap, yielded on distillation a distillate free from fusel oil, while the remaining residue of soap showed a strong odor of fusel oil.

From these observations accidentally made, Kletzinsky drew the following inferences:—

1. That by distillation with soap every variety of spirit, whiskey, or low wine can be obtained absolutely free from fusel oil.

2. That the fusel oil retained by the soap can be distilled off at a high temperature, and the soap can be re-used for rectifying purposes.

3. The percentage of alcohol in the distillate purified with soap is higher than in that rectified without soap, since the soap retains water.

4. 4 lbs. of soap are sufficient to remove the fusel oil from about 50 quarts of low wine. Under the most favorable circumstances, the soap will fix and retain 20 per cent. of fusel oil.

5. The soap to be used should be hard soda soap, free from volatile sebacic acids.

Chloride of lime in connection with charcoal is frequently used in German distilleries. The chloride of lime is stirred to a homogeneous fluid with *cold* water, and the mixture added to the spirit. After some time the supernatant clear liquid is drawn off and rectified, or the whole is put into the still.

In distilleries using caustic potassa for removing

the fusel oil from crude proof spirit, the proportion is about 2 kilogr. (4.4 lbs.) of caustic potassa and 2 kilogr. (4.4 lbs.) of pearl ash to 2750 liters (726.34 gallons).

When the distiller finds that an unusual quantity of fusel oil is present, the proportion of the salts is increased, and sulphuric acid is added, in order to improve the flavor of the spirit by giving rise to an ether. The salts are dissolved in about 8 liters (2.11 gallons) of liquid, and the sedimentary impurities removed by filtration. The solution is then mixed with the crude spirits, and distillation commenced. If the common still be employed, great attention must be paid to the fire, for if it be not slackened when the liquid first boils, there is much risk of the still running foul, as the boiling over through the neck of the still is called.

In rectifying faints, 80 underproof the following method is used: The spirit is mixed with the proper quantity of alkali, and the stills charged; the first portions that come over are collected separately till the spirit runs at about proof, when it is turned off into another receiver; the result of this operation, the common still being used, will be about 10 per cent. over proof. On rectifying a second time, the distillate at first marks 43 per cent., and is collected till it indicates 30; it is then conducted into another receiver until reduced to 10 per cent. over proof, and the residual portion, after this strength, is received in the faints back. A

third rectification will give a spirit of 53 per cent. over proof. In the second rectification, only one-half the quantity of salts employed in the first operation is made use of; and in the third it is customary to add about 2 kilogr. (4.4 lbs.) of animal charcoal and 5 kilogr. (11 lbs.) of coarse-grained common salt to every 400 liters (105.65 gallons) to cleanse the still.

A peculiar method for a partial purification of alcohol, which has been highly recommended, has recently been published by Beaurepaire. It is used in combination with the ordinary method of rectification by evaporation, and, it is claimed, increases the result considerably.

The process consists in a vigorous airing of the low wine to be purified at a temperature near the boiling point. The current of air, in passing through, removes the larger part of the foreign volatile constituents.

Fig. 28 represents the airing apparatus in connection with the rectification.

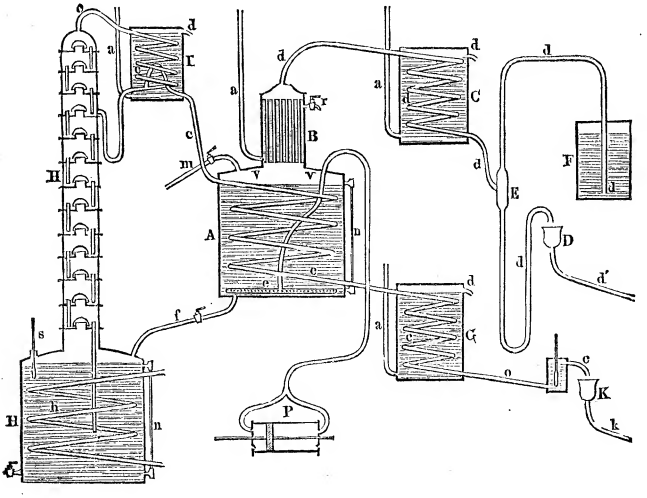
A is the receiver for the low wine to be aired, which is heated by means of the alcoholic vapors from the column, *H*, condensing in the coil, *c c c*.

A pump, *P*, forces the air through a suitably perforated coil on the bottom of *A*; this air is loaded with the oils volatilizing at 70° C. (158° F.) and passes with the vapors escaping at the same time into the vessel, *B*, whence the less volatile alcohol runs back into *A*, while the more volatile oils con-

dense mostly in *C*; in *E* the gases separate and pass out through water in *F*, while the strongly smelling liquid is discharged through *D*.

To regulate the temperature in *A*, an open steam pipe is provided; when the airing is interrupted there, the discharge of the oils at *D* ceases immediately.

Fig. 28.



The following parts of the apparatus deserve special mention:—

G, cooler for the alcoholic vapors not condensed in *A*; *o*, *c*, *K*, *K*, discharge pipes.

H, evaporating boiler (Champonnois's system).

a a a, cold water pipe.

r, regulating cock for the precipitation in *B*.
f, pipe for filling the still with aired low wine.
h, heating coal.
m, pipe for conducting the low wine to *A*.
n, gauge glass.
s, thermometer.

It is claimed that eight-tenths of the volatile oils are removed by means of this apparatus, and hence more pure alcohol is obtained in rectification than without airing.

IX.

PREPARATION OF LIQUORS.

A LARGE part of the alcoholic distillates of 80 to 82 per cent. is immediately used for the production of liquor by reducing them to a proper strength by an addition of water, and adding sometimes aromatic, bitter, and other substances.

As the fusel oil and other impurities adhering to the raw spirit are not removed, the product can only be very impure liquors, tasting strongly of fusel oil.

Liquors of a better quality, and almost entirely pure, can be prepared by mixing spirit of 90 to 94 per cent. with water. Besides this method—diluting spirit of different strength, and origin with water—there is another one which consists in ob-

taining the liquor of the required strength (40 to 50 per cent.) from mashes especially prepared and fermented for the purpose. This manner of producing liquors is in use in all countries, but varies according to the raw material and the flavor of the product, and the latter being regulated by the taste of the consumer, it is absolutely necessary that the liquor, to insure its sale, should always have the flavor which is desired by the public. This is the reason why the method of manufacturing liquors varies so much in different regions, and why distillers are apt to retain antiquated processes, and scorn improvements, in order to retain a certain flavor for their product.

1. *Cognac, or Brandy.*

In Southern France, where the distillation of wine is carried on on a large scale, most distilleries use Derosne's continuously working apparatus. But many of the smaller distilleries, which have a special reputation for the quality of their product, work with the simple still heated by steam, or in a water bath, as they claim that the use of Derosne's or any other apparatus is injurious to the flavor of the cognac, and deprives it of its fine aroma.

After the wine has been brought to the boiling point, it yields first a weak, turbid distillate, varying in flavor and aroma according to the nature of the wine used. But soon the liquor runs clear, and if the distillate is collected until it is no longer in-

flammable, the entire mixture is known as ordinary cognac.

This method is used by many distillers. But if a product of a finer quality is to be produced, the after run is collected by itself and distilled into spirit, or added to the succeeding distilling operation. The first run, which contains the aromatic taste and the finest flavor, is seldom separated. In order to lose nothing of the aroma, the wine is distilled but once, and in a simple still which is heated so slowly that only a weak uniform stream of cognac runs off. The after-run, which is separated, amounts to one-fifth or one-sixth of the whole. If the still has not been used for some time, the first run must be rejected, on account of a metallic taste. More or less spoiled wines give only two-thirds to three-quarters of a good product of varying quality; fore-run and after-run must be re-distilled, and they give even then only a poor product.

To the Montpellier and other cognacs, some burnt sugar is sometimes added, in order to give them the required color, which otherwise they only acquire by long storing in wood; the proportion is 1 to 2 grammes (15.43 to 30.86 grains) to the liter (2.113 pints).

Other ingredients are added to age the cognac, and also to disguise the peculiar taste derived from the origin of the wine from which it has been prepared.

To Imitate Armagnac cognac, add to 1 hectoliter

(26.4 gallons) of spirit, besides the necessary water :—

Infusion of nut shells, 1 liter (2.11 pints).

Infusion of bitter almond shells, 2 liters (4.22 pints).

Glucose, 3 liters (6.33 pints).

The following mixture is also used to prepare 1 hectolitre (26.41 gallons) of *Armagnac*:—

Rectified spirit of 85 per cent., 56 liters (14.79 gallons).

Ordinary rum, 2 liters (4.22 pints).

Water, 40 liters (8.56 gallons).

Glucose of 36° B. 2 liters (4.22 pints).

Dried liquorice root, 500 grammes (17.63 ozs.)

Black tea, 60 grammes (2.11 ozs.)

Cream of tartar, 2 grammes (30.86 grains).

Boracic acid, 1 gramme (15.43 grains).

The liquorice root is ground and boiled with half the quantity of water, the tea is drawn with 10 liters (2.64 gallons) of boiling water in a closed vessel, and the boracic acid dissolved in 2 liters (4.22 pints) of hot water. When all is cool, mix the alcohol, rum, glucose, and enough water to make 100 liters (26.41 gallons). The extracts are passed, before use, through a hair sieve, and the entire mixture is colored with burnt sugar.

Rochelle brandy is imitated, according to an English receipt, as follows: To 20 gallons of pure proof spirit add 2 gallons of Rochelle brandy, 4 pounds

of raisins, 4 ozs. of tincture of kino, 1 pint of syrup, and 1 oz. of acetic ether.

Color with sugar color, and allow it to stand ten days, though it may be used sooner.

There are a number of other methods for imitating brandy, but we would mention that in many parts of France the spirit is not mixed with pure water, but with great success, and in a manner which can be highly recommended, with *a special water*, prepared as follows:—

Collect rain water, allow it to settle and draw the supernatant clear water into barrels, and add 10 to 12 per cent. of whiskey of 58 per cent., or spirit of 85 per cent., to prevent spoiling. In the course of six to eight months or more, this water is especially adapted for diluting spirit, to which it imparts a peculiarly mellow taste.

The following method of preparing the water is also recommended: Put in an empty barrel, from which the head has been removed, 10 kilogr. (22 lbs.) of shavings and sawdust of white oak for every hectoliter (26.4 gallons) capacity, and then fill the barrel with water. After six to eight days draw off the water, which is thrown away, and re-fill the barrel with rain water, mixed with spirit in the proportion of 10 of water to 1 of spirit. After some time, the water acquires a color and taste, which it imparts to spirit mixed with it, and gives it that excellent taste known as *rancio*.

2. *Gin or Geneva*

Is a kind of ardent spirits manufactured in Holland, therefore called Hollands gin, to distinguish it from the gin manufactured in England; and both the Hollands and British gin differ entirely from the article generally sold by dealers under the name of gin or Hollands gin, the latter being generally nothing but pure spirits, flavored with juniper, turpentine, and small quantities of some of the aromatics, etc.

The peculiar and excellent flavor of Hollands gin depends on the particular mode of its manufacture, and not, as many suppose, on the large or small quantity of juniper berries employed, its flavor differing materially from the flavor extracted from juniper. A large majority of the Dutch distillers combine a little Strasburg turpentine and a small quantity of hops with the juniper berries before rectification, the fine aroma which distinguishes the best gin being partly due to the turpentine employed.

The materials employed in the distilleries of Schiedam are, two parts of unmalted rye. The mash vat, which serves also as the fermenting vat, has a capacity of about 700 gallons, being about 5 feet in diameter at the mouth, rather narrower at the bottom, and $4\frac{1}{2}$ feet deep; the stirring apparatus is an oblong rectangular iron grid made fast to a wooden pole. About a barrel (36 gallons) of water of a temperature of from 72° to 76° C.

(161.6° to 168.8° F.) is put into the mash vat for every 1½ cwt. of meal, after which the malt is introduced and stirred, and lastly the rye is added. Powerful agitation is given to the mixture till it becomes quite uniform. The mouth of the vat is then covered over with canvas, and further secured with a close wooden lid to confine the heat. It is left in this state for two hours. The contents being then stirred up once more, the clear spent wash of a preceding distillation is first added, and next, as much cold water as will reduce the temperature of the whole to 30° C. (86° F.). A pound of the best Flanders yeast is then introduced for every 100 gallons of the mashed material. The gravity of the fresh mash is generally from 33 to 38 lbs. per Dycas's hydrometer; and the fermentation is carried on from 48 to 60 hours, at the end of which time the attenuation is from seven to four pounds, that is, the specific gravity of the supernatant wash is from 1.007 to 1.004.

The distillers are induced, by the scarcity of brewer's yeast in Holland, to skim off a quantity of the yeast from the fermenting vats, and to sell it to the bakers, whereby they obstruct materially the production of spirit, though they probably improve its quality by preventing its impregnation with yeasty particles.

On the third day after the fermenting vat is set, the wash containing the grains is transferred to the still, and converted into low wines. To every 100

gallons of this liquor, 2 pounds of juniper berries, from three to five years old, are added, along with about ¼ lb. of salt; the whole is put into the low wine-still, and the fine Hollands spirits is drawn off by a gentle and well-regulated heat till the mixture becomes exhausted, the first and the last products being mixed together, whereby a spirit is obtained which possesses the peculiarly fine aroma of gin.

Gin has thus far proved more difficult to imitate than any of the other liquors, it being almost impossible to impart the exact flavor of true Hollands gin to any of its imitations.

We give in the following a few

Receipts for the Imitation of Gin, the products of which have, by good judges, been pronounced genuine articles.

1. To 20 gallons of pure spirit add 5 gallons of the variety of gin to be imitated; then take 1 lb. juniper berries, 2 drachms caraway seed, ½ oz. spirits of nitre, and 1 drachm of pure oil of turpentine. Digest for 8 days in 1 gallon of strong alcohol, agitating occasionally; filter through paper, add the liquor slowly to the spirit and gin, and mix thoroughly, adding 1 pint of simple syrup, or more if required.

2. To 20 gallons of pure spirit add, 2 drachms of oil of juniper, 1 drachm of pure oil of turpentine, and 20 drops of oil of caraway, all previously dissolved in 1 quart of strong alcohol; ½ ounce of citric

acid dissolved in sufficient water, and 1½ pints of simple syrup. Mix thoroughly and let stand two days.

3. To 20 gallons of pure spirit add, 1½ pints of simple syrup, ½ oz. of acetic acid, ½ pint of lemon juice. Then take 1¼ lbs. of juniper berries, 1 drachm of pure turpentine, and 2 drachms of fennel seed. Digest 8 days. Filter and add to the pure spirit. Mix and agitate for 5 minutes.

3. *Whiskey*

Is the name of the spirituous liquor manufactured by our distillers, and corresponds to the *eau de vie* of the French and the *Branntwein* of the Germans. The product obtained from the distillation of fermented wort is most esteemed. Barley, rye, and corn are the species of grain most commonly employed in this country for making whiskey. Barley is mostly taken, either partly or altogether in the malted state, while the other grains are not malted, but merely mixed with a certain proportion of barley malt to flavor the saccharine fermentation in the mashing.

Fine imitations of Scotch, Irish, and other whiskeys may be made by the following receipts:—

Scotch whiskey.—To 20 gallons of proof spirit add 4 gallons of Scotch whiskey, 30 drops of creasote dissolved in 1 pint of alcohol, ½ oz. of acetic acid, and 1 pint of simple syrup. Agitate thoroughly. It is at once fit for use, but the longer it stands the better, as age improves it.

Irish whiskey.—To 20 gallons of pure proof spirit add 4 gallons of Irish whiskey, 50 drops of creasote dissolved in 1 pint of alcohol, ½ oz. each of acetic acid and acetic ether, and 1 pint of simple syrup. Mix thoroughly.

Old Bourbon whiskey.—To 20 gallons of pure proof spirit add 3 gallons of Bourbon whiskey, 1 pint of simple syrup, 1 oz. of fusel oil (from corn) dissolved in alcohol, 1 oz. of tincture of cloves. Agitate thoroughly and color if required.

Monongahela whiskey.—To 20 gallons of pure proof spirit add ½ lb. of roasted barley, roasted and ground coarse like coffee, ½ oz. sweet spirit of nitre, 3 lbs. of dried peaches, 3 lbs. of sugar, 2 ozs. of allspice, and 1 oz. of cinnamon. Let it stand six days, agitate occasionally; draw off, and strain if necessary.

Apple whiskey.—To 20 gallons of pure spirit add, 3 gallons of good old apple whiskey, 1½ pints of syrup, and the juice of 2 pineapples. Mix thoroughly.

Fancy Brandies

are liquors made by uniting with pure spirit some aromatic, acidulous, or other ingredient, combined with a certain proportion of sugar or syrup, the peculiar taste or fragrance of which is imparted to the liquor; from which circumstance the different fancy brandies derive their names. The following receipts will be found excellent. Some consumers prefer the brandies well sweetened. The maker can,

at his own pleasure, add a large or small quantity of sugar or simple syrup; the other ingredients should be added according to the directions given, and care taken that the whole be thoroughly incorporated so as to insure a fine, clear, transparent brandy.

Blackberry brandy.—To 20 gallons of pure spirit add 6 gallons of blackberries, 8 gallons of water, 12 lbs. of loaf sugar, ½ oz. of unground cloves, and 1 oz. of unground cinnamon. Let it stand 20 days, draw off, strain and fine, if necessary.

Raspberry brandy.—Pour 20 gallons of pure proof spirit over 25 quarts of raspberries, add 4 gallons of water, 12 lbs. of loaf sugar, 1 oz. of unground cloves, and 1 oz. of unground cinnamon. Proceed according to the directions given for blackberry brandy.

Cherry brandy.—Pour 20 gallons of pure proof spirit over 25 quarts of bruised wild cherries. Let it stand 6 days, strain, and add 12 lbs. of loaf sugar. Let it stand 8 days, draw off and fine, if necessary.

Peach brandy.—Mix 20 gallons of pure proof spirit with 6 gallons of good peach brandy, 4 lbs. of loaf sugar, ½ drachm of essential oil of bitter almonds dissolved in alcohol, and ½ pint of orange flower water. Color, and let it stand for 6 days, when it is ready for use.

Rose brandy.—Add 5 gallons of water, 20 lbs. of sugar, 30 drops of oil of roses dissolved in 1 pint of alcohol, and ½ oz. of tartaric acid to 20 gallons of

pure proof spirit. Color with red sanders or tincture of rhatany. Let it stand 5 days, and it is ready for use.

Lemon brandy.—Pour 20 gallons of pure proof spirit over 20 sliced lemons, 16 lbs. of sugar, ¼ lb. of lemon peel and ½ oz. of crushed nutmeg. Let it stand, and draw off.

Orange brandy.—Add 25 sliced oranges, 15 lbs. of loaf sugar and 1 quart of good brandy to 20 gallons of pure proof spirit. Let it stand 14 days and draw off.

Pineapple brandy.—To 20 gallons of pure proof spirit add 10 pineapples sliced, 14 lbs. of loaf sugar, 2 quarts of good brandy and 1 oz. of tincture of saffron. Let it stand 10 days; then draw it off ready for use.

Lavender brandy.—Dissolve 2 drachms of oil of lavender in strong alcohol for 12 hours, then add it and 6 gallons of pure water, 1 oz. of tincture of cinnamon and 1 gallon of simple syrup to 20 gallons of pure proof spirit. Color with caramel, adding more lavender or syrup, if more flavor or sweetness is required.

Absinthe forms a considerable article of commerce and consumption, especially in France, where large quantities of it are manufactured in Pontarlier, Montpellier, and Lyons. In consequence of the presence of a large quantity of volatile oils (especially oil of anise and fennel), absinthe, when mixed with water, gives a milk-white liquid which is con-

sidered a proof of its good quality. It should have a mellow, agreeable, aromatic, and somewhat sweetish taste.

The following receipts are, according to Duplais, used for its manufacture on a large scale, the proportions being calculated for 100 liters (26.41 gallons) of liquor ready for use.

1. Large wormwood, dried and cleansed, 2.5 kilogr. (5.5 lbs.), green anise 5 kilogr. (11 lbs.), Florence fennel 5 kilogr. (11 lbs.), spirits of 85 per cent. 95 liters (25. 09 gallons).

Macerate the vegetable substances in a water-bath at least 12 hours, then add 45 liters (11.88 gallons) of water and distil off 95 liters (25.09 gallons). (For apparatus used see Fig. 29.)

The absinthe has now to be colored green. This is effected with: Small wormwood dried and cleansed 1 kilogr. (2.2 lbs.), dried spikes and blossoms of hyssop 1 kilogr. (2.2 lbs.), balm of Gilead, dried and cleansed, 0.5 kilogr. (1.1 lb.), and aromatic distillate (see above) 40 liters (10.56 gallons).

The wormwood is cut and the other herbs pounded in a mortar, and the whole slowly heated until the heat in the helmet of the apparatus indicates that the liquid has commenced to boil, when the fire is quickly extinguished. Before taking the mixture from the still, it is allowed to cool off entirely; it is then strained through a hair sieve and the remaining 55 liters (14.52 gallons) of distillate are

added. It is finally brought to 100 liters (26.41 gallons) of 74 per cent. by the addition of 5 liters (1.32 gallons) of water.

Of the other mixtures used for the same purpose, we will only mention that employed in Montpellier. The manner of preparing the liquor is the same as above.

2. Large wormwood, dried, 2.5 kilogr. (5.5 lbs.), green anise 6 kilogr. (13.2 lbs.), Florence fennel 4 kilogr. (8.8 lbs.), coriander seed 1 kilogr. (2.2 lbs.), angelica seed 0.5 kilogr. (1.1 lb.), and spirits of 85 per cent. 95 liters (25.09 gallons).

For coloring green: hyssop 750 grammes (26.45 ozs.), dry Moldavian balm 750 grammes (25.25 ozs.), and small wormwood 1 kilogr. (2.2 lbs.).

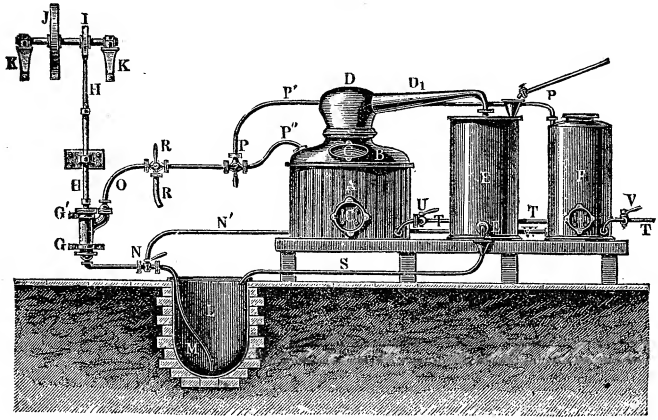
For all preparations we would remark that absinthe acquires its mellow taste only by storing, and that the vegetable substances, especially those used for coloring, must be very carefully selected, and freed from green and black leaves. By cleansing is understood that only the spikes of the plants are to be taken. Distillation should never be carried on to the end, as the taste of the liquor would be too strong, and less fine.

The distillation of absinthe is effected in a still, with a very flat helmet in a water or steam bath. The volatile oils passing over with the low wine are of great value for the succeeding operations. The coloring requires great care. The residue can be used for coloring a portion of the absinthe, and

is then redistilled, in order to regain the residue of spirit.

Fig. 29 represents the apparatus used for distilling absinthe. It consists of the following parts: *A*, a still covered with wood, which serves as a water-bath for the interior still, in which the herbs and liquid to be distilled are placed. *B*, cover of the still with aperture, *C*, for filling and emptying, and, *C'*, for removing the plants after distillation. *D*, the helmet with the pipe, *D'*; *E*, cooler, with

Fig. 29.



discharge, aperture, *E'*; *F*, coloring boiler with the necessary apertures and covers; *G G*,' pump; *H I J K*, motive parts of the pump; *L*, metal receiver set in the floor; *M*, suction-pipe of the pump; *N*, cock; *N' W*, suction-pipe from the color-

ing boiler; *O*, delivery pipe; *P*, three-way cock with pipe, *P'*, to the coloring boiler and pipe, *P''* to the still; *R R*, cock and pipe to the barrel; *S*, discharge pipe to the receiver; *T*, principal steam pipe from the boiler; *U*, steam-cock of the still; *V*, steam-cock of the coloring boiler.

This apparatus performs the different operations in an excellent manner by the use of one pump which charges the still, *A*, with water, conducts the distillate into the coloring boiler, and the finished product into the barrels. This is done in the following manner:—

Water and spirit, in a fixed proportion, are brought into the receiver, *L*, and the herbs into the still through the upper aperture; the conduit, *M G P P''*, is then opened, and the contents of *L* pumped into *A*. After closing the conduit, steam is introduced through *U*, when the distillate, which is now aromatized, but colorless spirit, runs off through *S*. This is now pumped from *L* through *M G P P'* into the coloring boiler, *F*, which has in the mean while been charged with herbs. When the herbs are extracted, the colored liquor is pumped out through *N'*, and conducted through *R* into the barrels, where the final mixture takes place.

X.

PREPARATION OF LIQUEURS OR CORDIALS.

UNDER the general term "liqueurs or cordials," we class all the aromatic and sweet spirituous beverages prepared from spirit or whiskey, aromatic vegetable substances and sugar.

The number of liqueurs, which can be prepared, is without limit, since not only every aromatic vegetable substance can be used, but, by mixing various proportions of several aromatic substances, the number of every variety of liqueurs can be increased at pleasure.

There may be several varieties of one kind of liqueur according to the quantity of sugar used in sweetening. The varieties containing most sugar, which in consequence are the sweetest and most thickly fluid, are called *crêmes*, while the special term *liqueurs* is applied to the less sweet, and that of *aqua vitæ* to the least sweet. The beverages known as *ratafias* are prepared by mixing fruit juices with spirit and sugar.

The good quality of the different kinds of liqueurs depends on the purity of the sugar and spirit, and the fineness of the aroma.

By the strength of liqueurs is understood the percentage of alcohol they contain. As a rule the percentage of alcohol must be the less the greater

the amount of sugar, since the sugar, by withdrawing water from the alcoholic fluid, renders the taste of alcohol more perceptible. Hence crêmes with 440 to 350 grammes (15.52 to 12.34 ozs.) of sugar to the liter (2.11 pints) require only from 36 to 40 per cent. Tr. of alcohol, liqueurs with 330 to 175 grammes (11.64 to 6.17 ozs.) of sugar to the liter (2.11 pints), should have from 40 to 43 per cent. Tr. of alcohol, and aqua vitæ, with 110 to 50 grammes (3.88 to 1.76 ozs.) of sugar to the liter (2.11 pints), 45 to 49 per cent. Tr. of alcohol.

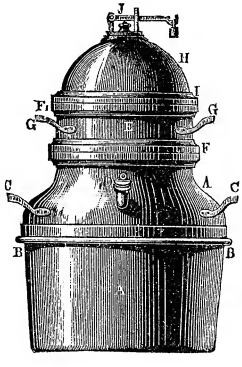
Generally speaking, the manufacture of liqueurs is a very simple operation. The aroma of any desired aromatic vegetable substance is incorporated with the sufficiently diluted alcoholic liquid, and the required amount of sugar, which is generally dissolved in water.

Like in all other spirituous liquors, the fine flavor, in which all the good qualities of the various constituents are blended together, is only acquired in liqueurs by long storing. To shorten the time, the liqueurs are aged by a special treatment, which consists in placing the newly-prepared mixture in a large vessel in a still with water, and after closing the helmet, gradually heating the water. When the helmet and neck of the still are hot, the heating is quickly interrupted, and the mixture allowed to cool before it is taken from the still.

The apparatus represented in Fig. 30 is recom-

mended by Duplais as practical and convenient. *A* is the still or boiler, which sets in a furnace up to the projecting rim, *B*. *C C* are handles for removing the apparatus from the fire, and *D* the aperture for the admission of water. *E* is the vessel for the reception of the mixture to be treated; it is provided with the handles, *G G*, and two hoops, *F F'*, the lower one of which fits exactly upon the corresponding one of the still, while the upper, *F'*, serves for the reception of the lid, *H*,

Fig. 30.



which is also provided with a hoop, *I*. The hoops, *I* and *F*, are luted with a suitable cement.

Materials for the Preparation of Liqueurs, and on the Manufacture of Liqueurs in General.—The principal materials required are spirit or whiskey, aromatic vegetable substances, or their aroma,

essential oils, sugar, water for diluting the spirit, and some coloring substances.

1. *Spirit.*

The spirit used in the preparation of liqueurs must be free from all odor; the smallest quantity of fusel oil would spoil the flavor. For strongly flavored liqueurs requiring but a small quantity of alcohol, spirit purified by charcoal in the cold way will do, especially if the aromatizing is effected by distillation. For ordinary and bitter aqua vitæ good raw spirit or whiskey is frequently used. For colorless liqueurs to be prepared without distillation, very pure spirit, free from all color, is absolutely necessary.

2. *Aromatic Vegetable Substances, and their Uses.*

The number of vegetable substances used for aromatizing liqueurs is very large, all kinds of herbs, seeds, roots, etc., excelling in an agreeable taste and odor, contributing their quota to the manufacture of liqueurs. Where the manufacturer cannot gather the substances himself, he should be careful to buy only the best materials and store them in a dry room, using them, however, as soon as possible, as they lose much of their flavor by age.

The vegetable substances, according to their constituents and the manner of using them, may be divided into three classes, the first embracing all

the substances employed on account of their percentage of essential oil, such as caraway seed, anise seed, celery seed, coriander seed, juniper berries, lemon peel, peppermint, orange blossoms, roses, bitter almonds, etc.

The essential oils are generally extracted from the flowers, fruit, leaves, or seeds, by distillation with water, the portion of the plant being suspended in the still by means of a bag or perforated vessel, so that there may be no danger of its being scorched by contact with the hot sides of the still, and contaminating the distillate with empyreumatic matters. The water which distils over always holds some of the essential oil in solution, and it is in this way that the fragrant waters are obtained. When the essential oil is present in large proportion, it collects as a separate layer upon the surface of the water, from which it is easily decanted. The oil which is dissolved in the water can be separated from it by saturating the liquid with common salt, when the oil rises to the surface, or by shaking it with ether which dissolves the oil and separates from the water, the ethereal solution floating upon its surface, and leaving the oil when the ether is evaporated.

The simplest manner of preparing liqueurs is to use the essential oils of commerce, provided they are pure, and the manufacturer should be particularly careful to procure his supply from a reliable source, as especially the more expensive kinds are fre-

quently adulterated by the addition of oil of turpentine, lavender oil, or lemon oil, whose smell is masked by that of the genuine oils. Another adulteration which, though it does not injure the quality of the oil, makes it of less value, consists in mixing the oil with spirit. It is readily recognized by placing equal volumes of water and oil in a small test-tube and shaking. After quieting, the oil separates from the water, the volume of oil, in case it is free from spirit, remaining as large as before, while, if spirit is present, the volume of oil decreases by the water withdrawing the spirit.

To the second class of vegetable substances used in the preparation of liqueurs, which embraces such as contain bitter extractive substances besides essential oils, belong orange peel, pomegranate seeds, vanilla, cinnamon, cloves, calamus root, galanga, wormwood, roasted coffee, etc. Some of these substances are rich in essential oil, while others contain but a small quantity. If both the essential oil and the extractive substances are to be incorporated in the liqueur, alcohol of, at the utmost, 70 per cent. Tr. is poured over the comminuted vegetable substances, and the mass allowed to stand for some time. Extraction is either effected at an ordinary temperature or at a gentle heat. In the first case the term *maceration* is applied to the operation, and in the latter, *digestion.*

The alcohol dissolves, besides the essential oil, all the resinous, bitter, and coloring substances

which render the tincture, as such extract is called, more or less colored. The concentration of the tincture depends on the quantity of alcohol used, it being advisable to prepare a very concentrated one, and in preparing liqueurs, adding a sufficient quantity to the mixture of spirit and water, and then sweetening.

Extraction is effected by pouring alcohol over a measured or weighed quantity of vegetable substances suitably comminuted in a large glass bottle, corking the latter tightly, and allowing it to stand for some time with occasional shaking. After pouring off the tincture, the residue is placed in a clean linen bag and pressed out, the resulting liquid being added to the rest. Filtering is not necessary, as the tincture becomes clear by standing.

Tinctures obtained from vegetable substances of the second class, which contain much bitter substance in proportion to essential oil, give an unpleasant taste to liqueurs prepared with them. To produce aromatic and agreeable liqueurs with such substances, a tincture is prepared from a small quantity of them, and a distillate from a large quantity and both tincture and distillate in due proportion are used.

The third class of vegetable substances used in the preparation of liqueurs, comprises such fresh fruits as raspberries, cherries, strawberries, oranges, pineapples, etc. The fruits are macerated, and the juice obtained by pressing is mixed with a third or

half of its quantity of alcohol, and allowed to stand. The alcohol separates the slimy parts, leaving behind a clear alcoholic liquid which can be kept, and is well adapted for the preparation of liqueurs.

3. *Sweetening the Liqueurs.*

It is best to use only crystallized sugar. For sweetening ordinary liqueurs, it suffices to dissolve the sugar in water, and add the solution to the mixture, but for the finer varieties, it is absolutely necessary to boil the sugar to a certain consistency with water. The boiling of the sugar is effected in the following manner. Generally an allowance of 0.25 liter (0.52 pint) of water is made for 500 grammes (1.1 lb.) of sugar. Place the sugar, broken into small pieces, in a capacious boiler, and after pouring the water over it, place the boiler over a gentle fire, and when ebullition commences, add the white of one egg, beaten to froth, to every 2 kilogr. (4.4 lbs.) of sugar. The white of egg separates the impurities, which on coming to the surface are removed with a skimmer, this operation being continued until no more scum is formed, and the solution of sugar remains clear. After boiling for one hour, the solution is of sufficient consistency to be added to the liqueurs, though for the finest varieties it is best to allow the sugar to boil somewhat longer, until large bubbles are formed.

The consistency to which the sugar is to be boiled depends on the purpose for which it is to be used.

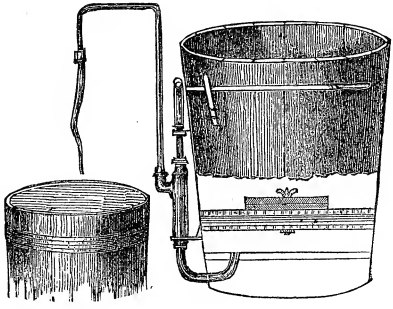
For ordinary purposes, it is sufficient to boil the sugar constantly for one hour over a steady, gentle fire, while for the finest varieties, one and a half to two hours will be required.

4. *Preparation of Liqueurs.*

The largest number of liqueurs are prepared cold, *i. e.*, either by mixing an alcoholic solution of essential oil with warm aqueous solution of sugar, or by adding to the mixture tinctures or essences, and diluting the whole with the required quantity of water. Every liqueur appearing turbid after mixing, clarification becomes necessary, which is effected for fine liqueurs by adding to every hectoliter (26.4 gallons) 25 grammes (0.88 ozs.) of gelatine dissolved in 0.5 liter (1.05 pint) of water, and allowing it to rest quietly. For other varieties it is recommended to add, first, a solution of 12 grammes (0.42 ozs.) of alum in 0.5 liter (1.05 pint) of water, and then a solution of 3 grammes (46.29 grains) of soda in 0.5 liter (1.05 pint) of water. Filtering is, under all circumstances, preferable, the operation being much accelerated by decreasing the pressure of air. Fig. 31 represents an apparatus constructed for the purpose. The liquid to be filtered is placed in the vessel provided with a pump, and forced into the other vessel. The filtering vessel is provided with a double perforated bottom upon which are placed suitable pieces of felt, upon which lies the fluid to be filtered. The space under the bot-

tom is first freed from air, which facilitates the passage of the liquid to be filtered. The apparatus

Fig. 31.



occupies but little space, and can be easily transported. Its capacity is considerable; 50 to 200 liters (13.2 to 52.7 gallons) can, according to the size of the apparatus, be filtered in eight to ten minutes.

5. *Coloring the Liqueurs.*

Liqueurs are generally colored after filtering, the coloring substances used in each case being given with the annexed receipts. The colors generally used are blue, brown, dark and pale yellow, green, and red, and the corresponding intermediate shades.

A large number of liqueurs, such as anise, anisette, bergamot, calamus, cummin, maraschino, etc., are not colored.

Blue is used for vanilla and violet.

Brown, for coffee liqueur, chocolate liqueur, curacoa and most bitters.

Dark yellow and *orange*, for bergamot, barbados, pomegranate, muscatel, etc.

Pale yellow, for anise, lemon, fennel, persico, orange, etc.

Green, for absinthe, peppermint, balm, etc.

Red, for raspberry, strawberry, cherry, rose, etc.

The manner of coloring liqueurs is very simple. All that is required is to add a sufficient quantity of the respective coloring substance to obtain the desired shade. For coloring large quantities, a measured or weighed sample is colored, and a note made of the exact quantity of coloring substance used, and from this the quantity required for the entire lot is calculated.

The reddish-brown color generally given to bitter liqueurs is produced with tincture of caramel and cherry juice. It is best to add, according to the shade to be produced, first of the one and then of the other. If, for instance, a more brownish shade is desired, the liqueur is first colored brown and sufficient cherry juice is then added to produce the desired shade, and *vice versa*.

To liqueurs to be colored pale yellow, pale red, pale blue, etc., the coloring substance must be very carefully added, as a few drops of a concentrated coloring tincture are frequently sufficient to make the liqueur too dark. Care in coloring liqueurs cannot be sufficiently dwelt upon, as, though it

exerts no influence upon the quality, the appearance of the liqueur is of great importance, and many customers judge the quality from the color.

6. *Storing Finished Liqueurs.*

It is best to keep liqueurs in bottles well-corked. Bottled liqueurs kept in a cool place gain in quality by age, and their flavor becomes finer and more agreeable, frequently reaching the highest degree of perfection only after having been kept for a number of years. Such liqueurs, though they are not often found in commerce, are highly valued, and bring a very high price.

A principle requisite for keeping liqueurs in bottles is to secure them with air-tight clean corks and tinfoil caps. Wormy corks should be rejected. The use of sealing-wax cannot be recommended, since in case the cork should not fit tightly, the sealing-wax is dissolved by the alcohol in the liqueur, imparting to the latter a disagreeable taste.

Storing liquors in barrels cannot be recommended, as by long keeping they lose strength and aroma.

7. *Substances for Coloring Liqueurs.*

1. Bilberry juice is more used for coloring violet than blue. It is produced by boiling ripe bilberries with a small quantity of water for a short time, and pressing after cooling. The juice is compounded with $\frac{1}{4}$ its volume of alcohol, and kept in well-stoppered bottles.

2. *Caramel tincture.*—Boil in a copper or brass pan at a moderate heat 1 kilogr. (2.2 lbs.) of sugar, 30 grammes (1.05 oz.) of crystallized soda and 0.5 liter (1.05 pint) of water, until the mass commences to turn brown. A sample dropped upon paper should not stick, but at the same time be of a sufficiently dark color. When this has been effected take the pan from the fire and compound the mixture with 1 liter (2.11 pints) of water and 1 kilogr. (2.2 lbs.) of alcohol of 90 per cent. Tr., allow the whole to digest a few days, then filter and keep for use.

3. *Oak bark tincture.*—Digest 1 kilogr. (2.2 lbs.) of oak bark cut in small pieces in 3 kilogr. (6.6 lbs.) of spirit of 90 per cent. Tr. for 8 days, and filter.

4. *Yellow color.*—*a.* Digest 31 grammes (1.09 ozs.) of genuine saffron in 2 liters (4.22 pints) of alcohol for a few days, and filter.

b. Macerate 0.5 kilogr. (1.1 lb.) of comminuted ginger in 2 kilogr. (4.4 lbs.) of alcohol, of 85 per cent. Tr., for eight days, and then pour off the clear liquid.

c. Pour 1 kilogr. (2.2 lbs.) of alcohol of 90 per cent. Tr. over 240 grammes (8.46 ozs.) of turmeric, coarsely powdered, digest for 8 days, then filter.

5. *Green color.*—*a.* Boil 2 parts of liquid wash blue, and 1 part of turmeric with some alum, and filter.

b. Dissolve 60 grammes (2.11 ozs.) of turmeric, 15 grammes (0.52 oz.) of wash blue and 15 grammes

(0.52 oz.) of burnt alum in water, let the mixture stand 4 to 5 days, and pour off the clear liquid.

6. *Indigo tincture.* — Comminute as much as possible 1 part of best indigo. Place the powder in a porcelain mortar, and pour 4 parts of nitric acid over it. Mix the ingredients as intimately as possible, and after allowing it to stand quietly for two or three days, add, drop by drop, 12 parts of water, constantly stirring the mixture with a glass rod. Let it stand 2 to 3 hours, then add in small portions 3 parts of fresh slacked lime, and the same quantity of chalk, being careful not to add a fresh portion until the effervescence produced by the preceding one has subsided, which is promoted by constant stirring. Finally add 6 parts of alcohol of 90 per cent. Tr., and filter the liquid.

7. *Purple color* is produced with archil, water, and some alum.

8. *Red color.*—*a.* Pour 250 grammes (8.81 ozs.) of boiling water over 16 grammes (0.56 oz.) of powdered cochineal, and filter. The color will be more or less intense, according to the quality of the cochineal.

b. Digest in a close vessel for 48 hours 31 grammes (1.09 oz.) of sanders wood in 2 liters (4.22 pints) of alcohol of 34 per cent., and filter the liquid.

Various kinds of fruit juices, such as cherry juice, raspberry juice, etc., are frequently used for coloring liqueurs red.

9. *Violet color.*—Digest 30 grammes (1.05 oz.) of powdered cochineal in 2 kilogr. (4.4 lbs.) of alcohol for 4 to 6 days, then filter and add to the filtrate 5 grammes (0.17 oz.) of burnt alum and 10 grammes (0.35 oz.) of spirit of sal ammoniac.

10. *Aniline colors*, when guaranteed as free from poison, are preferable to all other colors for coloring liqueurs, but care must be had not to expose the liqueurs to the sun, as these colors fade very easily.

XI.

RECEIPTS FOR LIQUEURS.

I. *Ordinary Liqueurs.*

Anise liqueur.—Dissolve 7.5 grammes (0.26 oz.) of anise oil and 1.25 grammes (19.29 grains) of badian oil in 6 liters (1.58 gallons) of alcohol of 90 per cent. Tr., compound with a solution of 3 kilogr. (6.6 lbs.) of sugar, in 7 kilogr. (15.4 lbs.) of water, and filter through white blotting paper.

Anisette.—Dissolve 7.5 grammes (0.26 oz.) of anise oil and 18 drops of oil of bitter almonds in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., add a solution of 2.5 kilogr. (5.5 lbs.) of sugar in 6 liters (1.58 gallon) of water, and filter.

Orange liqueur.—Digest for 4 days 0.5 kilogr.

(1.1 lb.) of comminuted fresh orange peel in 8 liters (2.11 gallons) of spirit, and after clarification add 12 kilogr. (26.4 lbs.) of fine sugar syrup, and filter.

Angelica liqueur.—Digest in a warm place for about 4 days, 240 grammes (8.46 ozs.) of lemon peel, 150 grammes (5.29 ozs.) of pomegranate peel, 15 grammes (0.52 oz.) of mace, 10 grammes (0.35 oz.) of nutmeg, 65 grammes (2.29 ozs.) of cassia, 60 grammes (2.11 ozs.) of cloves, 30 grammes (1.05 oz.) of orris root, 60 grammes (2.11 ozs.) of rosemary leaves, 50 grammes (1.76 oz.) of lavender leaves, 65 grammes (2.29 ozs.) of orange blossoms, 10 grammes (0.35 oz.) of vanilla, and 65 grammes (2.29 ozs.) of bruised juniper berries, in 19 liters (5 gallons) of alcohol, of 90 per cent. Tr., filter and mix the filtrate with a solution of 12 kilogr. (26.4 lbs.) of sugar in 12.5 liters (3.3 gallons) of water.

Aqua blanca.—Dissolve 30 drops of oil of lemon, 27 of cedar-oil, 33 of oil of balm, 30 of oil of peppermint, 2.5 grammes (38.58 grains) of tincture of vanilla, and 2 grammes (30.86 grains) of essence of ambergris in 6 kilogr. (13.2 lbs., of alcohol of 90 per cent. Tr., add a solution of 3 kilogr. (6.6 lbs.) of sugar in 6 liters (1.58 gallons) of water, and filter.

Aromatic liqueur.—Compound 30 drops of oil of lemon, 24 of oil of rosemary, 27 of lavender oil, 30 of oil of peppermint, 27 of oil of angelica, 27 of oil of sweet marjoram, and 33 of oil cardamom with

6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., add 2.5 kilogr. (5.5 lbs.) of sugar dissolved in 6 liters (1.58 gallons) of water, and filter.

Baldrian liqueur.—Dissolve 80 drops of oil of valerian, 40 of oil of lemon, 20 of oil of angelica, and 20 of oil of calamus in 5 kilogr. (11 lbs.) of alcohol of 90 per cent. Tr., sweeten with 2.25 kilogr. (4.95 lbs.) of sugar dissolved in 5 liters (1.32 gallons) of water, and filter.

Berlin bitters.—Dissolve 80 drops of juniper oil, 80 of oil of coriander, 40 of oil of angelica, 40 of badian oil, and 44 of oil of ginger in 5.5 kilogr. (12.1 lbs.) of alcohol of 80 per cent. Tr., add 6.5 liters (1.71 gallons) of water and 0.5 kilogr. (1.1 lbs.) of sugar, and filter. Color brown.

Bishop liqueur.—Digest for 6 to 8 days, 5 liters (1.32 gallons) of cherry juice, 500 grammes (1.1 lbs.) of pomegranates, 165 grammes (5.82 ozs.) of pomegranate peel, 75 grammes (2.64 ozs.) of lemon peel, 90 grammes (3.17 ozs.) of cinnamon flowers and 100 grammes (3.52 ozs.) of cloves in 18 liters (4.75 gallons) of alcohol of 90 per cent. Tr., filter, add 10 liters (2.64 gallons) of wine, and sweeten with 10 kilogr. (22 lbs.) of brown sugar, dissolved in 9 liters (2.38 gallons) of water.

Bitter Rossoli.—Digest 240 grammes (8.46 ozs.) of pomegranates, 120 grammes (4.23 ozs.) of sandal wood, and 1 kilogr. (2.2 lbs.) of pomegranate peel in 48 kilogr. (105.6 lbs.) of good rye whiskey, filter and

sweeten with 1.5 kilogr. (3.3 lbs.) of sugar dissolved in 0.5 liter (1.05 pint) of water.

Cardinal de Rome.—Dissolve 7.5 grammes (0.26 oz.) of oil of lemon, 4 grammes (0.14 oz.) of oil of cloves, 40 drops of nutmeg oil, 20 drops of cinnamon oil, and 2.5 grammes (38.58 grains) of gray ambergris in 10 kilogr. (22 lbs.) of spirit of wine, sweeten with a solution of 5 kilogr. (11 lbs.) of sugar in 10 liters (2.64 gallons) of water, and filter.

Christofle.—Dissolve 80 drops of oil of orange peel, 60 of oil of lemon, 40 of oil of cinnamon, 40 of oil of balm, 32 of oil of cloves, and 24 of oil of mace, in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr.; add a solution of 2.5 kilogr. (5.5 lbs.) of sugar in 7 liters (1.85 gallons) of water, and filter.

Citronelle.—Comminute 240 grammes (8.46 ozs.) of lemon peel, 90 grammes (3.17 ozs.) of orange peel, 7.5 grammes (0.26 oz.) of nutmegs, and 5 grammes (0.17 oz.) of cloves, digest the mass in 7 kilogr. (15.4 lbs.) of alcohol of 90 per cent. Tr., press out, filter, and add 3 kilogr. (6.6 lbs.) of sugar dissolved in 7 liters (1.85 gallons) of water. Color yellow.

Curacoa.—Comminute 420 grammes (14.81 ozs.) of fresh orange peel, 60 grammes (2.11 ozs.) of cinnamon, and 7.5 grammes (0.26 ozs.) of nutmeg, pour 7 kilogr. (15.4 lbs.) of alcohol over the substances, and let them digest for 8 to 10 days, and compound the filtered liquid with a solution of 3 kilogr. (6.6 lbs.) of sugar in 7 liters (1.85 gallons) of water.

French curacoa.—Dissolve 5 grammes (0.17 oz.) of oil of orange peel, 20 drops of oil of cinnamon, 12 drops of oil of mace, 2 grammes (30.86 grains) of tincture of vanilla, 2 grammes (30.86 grains) of raspberry essence, and 120 grammes (4.23 ozs.) of Jamaica rum in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., and add a solution of 3 kilogr. (6.6 lbs.) of sugar in 7 liters (1.85 gallons) of water.

Eau Américaine.—Dissolve 3 grammes (46.29 grains) of oil of orange blossoms, 2 grammes (30.86 grains) each of oil of balm and oil of lemon, and 24 drops each of oil of cinnamon, oil of cloves, and oil of mace in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with a solution of 2.75 kilogr. (6.05 lbs.) of sugar, in 7 liters (1.85 gallons) of water, filter and color pale red.

Eau d'amour.—Distil 375 grammes (13.22 ozs.) of bitter almonds, 376 grammes (13.26 ozs.) of fresh lemon peel, 186 grammes (6.56 ozs.) of cinnamon, 17 grammes (0.59 oz.) of cloves, 254 grammes (8.96 ozs.) of lavender blossoms, 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr., and 18 liters (4.75 gallons) of water. Add to the distillate 8 liters (2.11 gallons) of muscat wine, 30 drops of essence of ambergris, 10 kilogr. (22 lbs.) of syrup, and 7 liters (1.85 gallons) of water, color rose color, and add some gold leaf.

Eau d'argent (*silver water.*) — Distil 500 grammes (1.1 lb.) of fresh lemon peel, 63 grammes (2.22 ozs.) of cloves, 49 grammes (1.72 oz.) each of

angelica seed and badian, 48 grammes (1.69 oz.) of orris, 63 grammes (2.22 ozs.) of cinnamon, and 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr. Add to the distillate 2 liters (4.22 pints) of balm water, and 12 kilogr. (26.4 lbs.) each of sugar syrup and water, color red, and mix some silver leaf rubbed fine with the liqueur.

Eau d'Ardelle.—Distil 125 grammes (4.4 ozs.) each of mace and cloves, 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr., and 18 liters (4.75 gallons) of water. Add to the distillate 15 liters (3.96 gallons) of syrup, and 13 liters (3.43 gallons) of water. Color the liqueur violet, and filter.

Eau cordiale.—Dissolve 5 grammes (0.17 oz.) of oil of lemon, 2 grammes (30.86 grains) of oil of fennel, 1.33 gramme (20.52 grains) of oil of cardamon, and 1 gramme (15.43 grains) each of oil of cloves and coriander oil in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., add a solution of 3 kilogr. (6.6 lbs.) of sugar in 6 liters (1.58 gallons) of water, and filter.

Eau d'absynth citronné.—Distil 2 kilogr. (4.4 lbs.) of fresh wormwood leaves, 20 grammes (0.705 oz.) of lemon peel, 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr., and 18 liters (4.75 gallons) of water. Add to the distillate 4 grammes (0.14 oz.) of oil of peppermint, 12 kilogr. (26.4 lbs.) of syrup, and 15 liters (3.96 gallons) of water.

Eau de la Cote.—Comminute 180 grammes (6.34 ozs.) of cinnamon, and the peels of 6 fresh lemons,

pour over them 11 liters (2.9 gallons) of spirit of wine, and let the whole digest three or four days. Then pour off the supernatant liquid, press out the residue, and add to the liquid 60 drops of oil of peppermint, 16 drops of oil of bergamot, 11 liters (2.9 gallons) of water, and 4 kilogr. (8.8 lbs.) of sugar, and filter.

Eau de Florence.—Distil 750 grammes (1.65 lb.) of fresh lemon peel, 93 grammes (3.28 ozs.) of cinnamon, 78 grammes (2.75 ozs.) of mace, 17 grammes (0.59 oz.) of cloves, 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr., and 18 liters (4.75 gallons) of water. Add to the distillate 63 grammes (2.22 ozs.) of oil of lemon, 2 liters (4.22 pints) of balm water, 12 liters (3.17 gallons) of water, and 12 kilogr. (26.4 lbs.) of sugar syrup.

Eau de Cypre.—Distil 185 grammes (6.52 ozs.) of orris, 186 grammes (6.56 ozs.) of lemon peel, 63 grammes (2.22 ozs.) of cinnamon, and 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr., and add to the distillate 61 drops of essence of bergamot, 17 grammes (0.59 oz.) of essence of ambergris, 6 liters (1.58 gallon) of orange-blossom water, 8 liters (2.11 gallons) of water, and 12 kilogr. (26.4 lbs.) of sugar syrup.

Eau de mille fleurs.—Dissolve 80 drops of oil of bergamot, 48 drops of oil of orange blossoms, 40 drops of oil of balm, 24 drops each of oil of lavender, oil of cinnamon, and oil of thyme, 16 drops of oil of cardamon, and 48 drops each of

essence of rose and tincture of vanilla in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with a solution of 3 kilogr. (6.6 lbs.) of sugar in 7 liters (1.85 gallons) of water, color pale green, and filter.

Eau nuptiale.—Distil 376 grammes (13.27 ozs.) of bitter almonds, 378 grammes (13.33 ozs.) of fresh lemon peel, 185 grammes (6.52 ozs.) of cinnamon, 32 grammes (1.12 oz.) of mace, 17 grammes (0.59 oz.) of cloves, 254 grammes (8.96 ozs.) of lavender blossoms, 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr., and 18 liters (4.75 gallons) of water. Add to the distillate 8 liters (2.11 gallons) of Muscat wine, 37 drops of essence of ambergris, 10 kilogr. (22 lbs.) of syrup, 7 liters (1.85 gallons) of water, and color rose color with an addition of some fine gold leaf.

Eau de Napoléon.—Dissolve 80 drops of oil of lemon, 60 of oil of cloves, 40 each of oil of bergamot and oil of cinnamon, 32 of oil of mace, 12 of oil of cardamon, 60 of tincture of vanilla, 48 of essence of rose, and 40 of essence of bitter almonds in 6 kilogr.* (13.2 lbs.) of spirit of 90 per cent. Tr., sweeten with a solution of 3.25 kilogr. (7.15 lbs.) of sugar in 7 liters (1.85 gallon) of water, color blue, and filter.

Eau de Paradise.—Distil 1 kilogr. (2.2 lbs.) of fresh lemon peel, 93 grammes (3.28 ozs.) of angelica root, 62 grammes (2.18 ozs.) of orris root, 79 grammes (2.78 ozs.) of calamus, 79 grammes (2.78 ozs.) of anise seed, 62 grammes (2.18 ozs.) of

* 1 kilogr. about = 1 liter = 2.113 pints.

rosewood, 32 grammes (1.12 ozs.) of cardamon, and 22 liters (5.81 gallons) of alcohol of 90 per cent. Tr. Sweeten the distillate with 12 kilogr. (26.4 lbs.) of sugar syrup dissolved in 14 liters (3.69 gallons) of water, and color green with an addition of some silver leaf rubbed fine.

Eau royale.—Macerate 180 grammes (6.34 ozs.) of orris root in 10 kilogr. (22 lbs.) of spirit of wine for 10 to 12 days, pour off the supernatant liquid, press out the residue and add to the liquid 60 drops each of oil of cloves and oil of bergamot and 2.5 grammes (38.58 grains) of gray ambergris. Sweeten with a solution of 4 kilogr. (8.8 lbs.) of sugar in 10 liters (2.64 gallons) of water and allow the liqueur to stand for some time. Then pour off the supernatant clear liquid and filter the rest.

Eau stomachal.—Comminute 500 grammes (1.1 lb.) of pomegranate peel, 60 grammes (2.11 ozs.) each of coriander and cinnamon, 45 grammes (1.58 oz.) of cloves, and 15 grammes (0.52 oz.) each of mace and saffron. Pour 10 kilogr. (22 lbs.) of spirit of wine over the ingredients and let them digest from 10 to 15 days. Then pour off the supernatant clear fluid and press out the residue. Now pour 10 liters (2.64 gallons) of boiling water over 4 handfuls of peppermint, drain the water off, and dissolve in it 3 kilogr. (6.6 lbs.) of sugar, and add this to the cold liqueur. Let it stand 3 to 4 weeks, then pour off the supernatant clear liqueur, and filter the residue.

English bitters.—Compound 80 drops of oil of pomegranate peel, 60 of oil of angelica, 40 of oil of wormwood, 24 of oil of marjoram, and 16 of oil of cardamon with 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., and sweeten with 2.5 kilogr. (5.5 lbs.) of sugar dissolved in 7 liters (1.85 gallon) of water. Color brown and filter.

Golden water.—Dissolve 2 grammes (30.86 grains) each of oil of lemon and orange peel, 40 drops each of oil of cinnamon and oil of rosemary, 20 drops of oil of cardamon and 24 drops each of oil of mace and oil of cloves in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., and sweeten with 2.75 kilogr. (6.05 lbs.) of sugar dissolved in 7 liters (1.85 gallons) of water. Then add 3 grammes (46.29 grains) of essence of orange blossoms, filter and add some gold leaf rubbed fine.

Greek bitters.—Dissolve 80 drops of oil of cinnamon, 48 of oil of wormwood, 40 each of oil of angelica and oil of calamus, 24 each of oil of mace, oil of cloves, and oil of bitter almonds, and 12 of oil of cardamon in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with the syrup of 2.75 kilogr. (6.05 lbs.) of sugar and 7 liters (1.85 gallons) of water, filter and color reddish-brown.

Hamburg bitters.—Dissolve 120 drops of oil of cinnamon blossoms, 40 each of oil of cloves, oil of calamus, and oil of wormwood, 24 of oil of mace, and 20 of oil of cardamon in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten the solution

with the syrup from 2.5 kilogr. (5.5 lbs.) of sugar and 6 liters (1.58 gallon) of water, color brown and filter.

Jesuit drops.—Digest in a glass bottle for 8 days, 600 grammes (21.16 ozs.) of powdered guaiacum resin, 450 grammes (15.87 ozs.) of sassafras wood in small pieces, and 30 grammes (1.05 oz.) of black Peruvian balsam in 3.25 kilogr. (7.15 lbs.) of spirit of wine, strain through a cloth, and filter.

Cherry liqueur.—Mix 6 kilogr. (13.2 lbs.) of fresh cherry juice with 3 kilogr. (6.6 lbs.) of alcohol of 90 per cent. Tr., let the mixture digest 8 days, then add 3.5 kilogr. (7.7 lbs.) of sugar, and filter.

Royal bitters.—Dissolve 80 drops of oil of lemon, 40 each of oil of balm and oil of sage, 60 of tincture of vanilla, 40 each of oil of marjoram and oil of wormwood, and 24 of oil of mace in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with the syrup from 2.75 kilogr. (6.05 lbs.) of sugar and 7 liters (1.85 gallons) of water, color, and filter.

Crambambuli.—Compound 4 grammes (0.14 oz.)of oil of cloves, 3 grammes (0.105 oz.) of oil of mace, 2 grammes (30.86 grains) of oil of cinnamon, and 1.33 grammes (20.52 grains) of oil of cardamon with 7 kilogr. (15.4 lbs.) of alcohol of 90 per cent. Tr., sweeten with the syrup from 2.5 kilogr. (5.5 lbs.) of sugar, and 6 liters (1.58 gallon) of water, color, and filter.

Peppermint liqueur.—Dissolve 4 grammes (0.14 oz.) of oil of curled mint, 40 drops of oil of balm, and 20 of oil of peppermint in 6 kilogr. (13.2 lbs.)

of alcohol of 90 per cent. Tr., sweeten with the syrup from 3 kilogr. (6.6 lbs.) of sugar, and 7 liters (1.85 gallon) of water, color green, and filter.

Cumin liqueur (Kümmel).—Dissolve 7.5 grammes (0.26 oz.) of cumin oil and 15 grammes (0.52 oz.) of anise oil in 7 kilgr. (15.4 lbs.) of alcohol of 90 per cent. Tr., sweeten with the syrup from 3 kilogr. (6.6 lbs.) of sugar and 7 liters (1.85 gallon) of water, and filter.

Lait de vieillesse.—Pour 12 liters (3.17 gallons) of whiskey of 22 per cent. over 500 grammes (1.1 lb.) of orange-blossom water, and 32 drops of Peruvian balsam, and sweeten with 4 kilogr. (8.8 lbs.) of sugar dissolved in 2 liters (4.22 pints) of water.

Stomach drops.—Comminute 15 grammes (0.52 oz.) each of worm-wood, holythistle, centaury, gentian, salt of tartar, and the peels of 4 pomegranates, add 1 liter (2.11 pints) of good whiskey, and after digesting for a few days in a warm place, strain through a cloth.

Danzig stomach liqueur.—Compound 50 drops of oil of pomegranate, 20 each of oil of calamus and oil of juniper, 10 each of oil of anise and oil of curled mint, and 6 each of lavender blossoms and oil of cloves in 5 kilogr. (11 lbs.) of alcohol, sweeten with 2 kilogr. (4.4 lbs.) of sugar dissolved in 5 kilogr. (11 lbs.) of water, color red, and filter.

Stomach elixir.—Distil 95 grammes (3.35 ozs.) of pomegranate peel, 20 grammes (0.705 oz.) of chamomile flowers, 30 grammes (1.05 oz.) of curled mint,

65 grammes (2.29 ozs.) of lemon peel, 20 grammes (0.705 oz.) of angelica root, 35 grammes (1.23 oz.) of cumin seed, 65 grammes (2.29 ozs.) of juniper berries, 95 grammes (3.35 ozs.) of badiane, 25 grammes (0.88 oz.) of ginger, 20 grammes (0.705 oz.) of cardamon seeds, 15 grammes (0.52 oz.) of angelica leaves, 35 grammes (1.23 oz.) of calamus root, 15 grammes (0.52 oz.) each of coriander seeds and galanga, 30 grammes (1.05 oz.) each of bay leaves and cloves, 60 grammes (2.11 ozs.) of orris root, 15 grammes (0.52 oz.) each of cinnamon blossoms and wormwood, 20 grammes (0.705 oz.) of peppermint, 30 grammes (1.05 oz.) of gnaphalium blossoms, 60 grammes (2.11 ozs.) of pomegranate seeds, and 95 grammes (3.35 ozs.) of cinnamon, with 16.5 liters (4.36 gallons) of alcohol of 90 per cent. Tr., and 10.5 liters (2.77 gallons) of water, and filter the distillate.

Maraschino.—Dissolve 2 grammes (30.86 grains) of oil of orange blossoms, the same quantity of oil of bitter almonds and essence of cognac, and 4 grammes (61.72 grains) of essence of raspberry in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr.; sweeten with 3 kilogr. (6.6 lbs.) of sugar dissolved in 6 liters (1.58 gallon) of water, and filter.

Mogador.—Dissolve 40 drops each of oil of wormwood, oil of calamus, oil of peppermint, and oil of lemon peel, and 20 drops each of oil of cinnamon, oil of cloves, oil of ginger, and oil of balm in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr.,

sweeten with 2.5 kilogr. (5.5 lbs.) of sugar dissolved in 4 liters (1.05 gallon) of water, color red with huckleberry juice, and filter.

Non plus ultra.—Mix 120 drops of oil of bitter almonds and 40 each of oil of cinnamon, oil of angelica, and oil of coriander with 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with 3 kilogr. (6.6 lbs.) of sugar dissolved in 7 liters (1.85 gallons) of water, color rose color, and filter.

Parfait d'Amour.—Dissolve 80 drops of oil of lemon, 40 of oil of cinnamon, 30 of oil of bergamot, 20 of oil of cloves, 16 of oil of nutmeg, and 10 of oil of lavender blossoms, or better, of oil of rosemary, in 10 kilogr. (22 lbs.) of alcohol, sweeten with 4 kilogr. (8.8 lbs.) of sugar dissolved in 10 liters (2.64 gallons) of water, color pale red, and filter.

Persico.—Dissolve 7.5 grammes (0.26 oz.) of oil of bitter almonds, and 3 grammes (46.3 grains) of essence of orange blossoms in 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with 3 kilogr. (6.6 lbs.) of sugar dissolved in 7 liters (1.85 gallon) of water, and filter.

Polska wodka.—Compound 60 drops of oil of lemon, 40 of oil of balm, 32 each of oil of lavender, oil of wormwood, oil of mace, and oil of juniper, 30 drops of oil of marjoram, and 20 each of oil of cardamon and oil of ginger in 7 kilogr. (15.4 lbs.) of alcohol of 90 per cent. Tr., sweeten with a solution of 3 kilogr. (6.6 lbs.) of sugar in 6 liters (1.58 gallon) of water, and filter.

Pomegranate liqueur.—Cut up 1 kilogr. (2.2 lbs.) of pomegranate peel, freed from the pulp, and 60 grammes (2.11 ozs.) of lemon peel, add 30 grammes (1.05 ozs.) of coarsely powdered cinnamon, and digest the substances with 4 kilogr. (8.8 lbs.) of alcohol of 85 per cent. for eight days with frequent shaking. Then strain through a cloth, and press out the residue. Now dissolve 0.75 kilogr. (1.65 lb.) of sugar in 2.5 liters (5.28 pints) of water, mix the two liquids, and filter.

Rossolio de Turin.—Comminute 540 grammes (19.04 ozs.) of fresh rose leaves, 240 grammes (8.46 ozs.) of fresh jasmine blossoms, 210 grammes (7.4 ozs.) of fresh orange blossoms, 30 grammes (1.05 oz.) each of orris root and cinnamon, and 7.5 grammes (0.26 oz.) each of cloves and vanilla. Digest the ingredients with 6 kilogr. (13.2 lbs.) of spirit of wine from eight to twelve days, placing the vessel in a warm place; then pour off the supernatant liquid, press out the residue, and sweeten with 3 to 3.5 kilogr. (6.6 to 7.7 lbs.) of sugar dissolved in 6 liters (1.58 gallons) of water. Allow the whole to repose three to four weeks, then pour off the clear liquid, and filter the turbid portion. The liqueur is colored red with cochineal, mulberry juice, or sweet cherry juice.

Rostopschin.—Compound 3 grammes (0.105 oz.) of anise oil, 48 drops of oil of coriander, 40 each of oil of cardamon, oil of fennel, and oil of cinnamon, and 2 grammes (30.86 grains) of essence of

cognac with 6 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with 3 kilogr. (6.6 lbs.) of sugar dissolved in 7 liters (1.85 gallon) of water, and filter.

Tivoli liqueur.—Dissolve 80 drops each of oil of coriander and oil of mace, and 40 drops each of oil of lemon, tincture of vanilla, oil of cinnamon and tincture of orris root in 5 kilogr. (13.2 lbs.) of alcohol of 90 per cent. Tr., sweeten with a solution of 2.5 kilogr. (5.5 lbs.) of sugar in 7 liters (1.85 gallon) of water, and color brown.

Vespetro.—Comminute and mix 16 grammes (0.56 oz.) each of angelica seeds, cumin seeds, coriander seed, and fennel seeds; digest the ingredients in 5 kilogr. (11 lbs.) of whiskey of 22 per cent. for eight days, distil in a water-bath, add the syrup from 2 kilogr. (4.4 lbs.) of sugar and 1.5 liter (3.16 pints) of water, color red, and strain.

Vienna bitter liqueur.—Dissolve 40 drops each of oil of bitter oranges, oil of wormwood, and oil of origanum, 32 drops of oil of calamus, 20 each of oil of peppermint and oil of marjoram, 24 of oil of coriander, 20 each of oil of anise, oil of thyme, and oil of lemon, and 12 of oil of cloves, in 7 kilogr. (15.4 lbs.) of alcohol of 90 per cent. Tr.; add 2.5 kilogr. (5.5 lbs.) of good red wine, sweeten with a solution of 3 kilogr. (6.6 lbs.) of sugar in 4 liters (1.05 gallon) of water, color red, and filter.

XII.

LIQUEURS PREPARED IN THE WARM WAY.

Absinthe liqueur. — Comminute 300 grammes (10.58 ozs.) of wormwood, 60 grammes (2.11 ozs.) each of angelica root, holy thistle, and anise seeds, 30 grammes (1.05 oz.) each of badiane seeds and coriander seeds, and 7.5 grammes (0.26 oz.) of fennel. Digest the ingredients with 10 kilogr. (22 lbs.) of alcohol and 4 liters (1.05 gallon) of water for two days, and distil until 11 liters (2.9 gallons) have passed over. Compound the distillate with 1 kilogr. (2.2 lbs.) of sugar, and color green.

Abbé water.—Comminute 750 grammes (26.45 ozs.) of dried lemon peel, 375 grammes (13.23 ozs.) of dried orange peel, 125 grammes (4.4 ozs.) of juniper berries, 62 grammes (2.18 ozs.) of sage, 250 grammes (8.81 ozs.) of anise seeds, and 62 grammes (2.18 ozs.) of mint. Digest the ingredients in 22 kilogr. (48.4 lbs.) of alcohol and 18 liters (4.75 gallons) of water for some time, then distil until 19 kilogr. (41.8 lbs.) have passed over, sweeten the distillate with 24 kilogr. (52.8 lbs.) of sugar syrup mixed with 15 liters (3.96 gallons) of water, and color red with the juice of black cherries.

Aqua vitæ.—Comminute 22.5 grammes (0.79 oz.) each of fennel and anise, 7.5 grammes (0.26 oz.) each of cloves, cardamons, cubebs, and galanga;

digest the ingredients with 2 liters (4.22 pints) of whiskey for 2 days, and distil. Sweeten the distillate with sugar according to taste, and filter.

Barbados liqueur.—Comminute 180 grammes (6.34 ozs.) each of lemon peel and orange peel, 60 grammes (2.11 ozs.) of mace, 30 grammes (1.05 oz.) each of cloves, and bitter almonds, 15 grammes (0.52 oz.) of ginger and 7.5 grammes (0.26 oz.) each of cardamon and anise. Digest the ingredients in 10 kilogr. (22 lbs.) of alcohol and 3.5 liters (3.69 quarts) of water for 2 days; then distil until 12 kilogr. (26.4 lbs.) have passed over, sweeten the distillate with 3 kilogr. (6.6 lbs.) of sugar and filter.

Beaume consolateur.—Distil 24 kilogr. (52.8 lbs.) of whiskey of 22 per cent. 16 grammes (0.56 oz.) of mace and 8 liters (2.11 gallons) of distilled water until 12 to 14 kilogr. (26.4 to 30.8 lbs.) of liqueur have passed over; then add the syrup prepared from 10 kilogr. (22 lbs.) of sugar and 8 liters (2.11 gallons) of distilled water, 90 grammes (3.17 ozs.) of essence of jasmine, 60 grammes (2.11 ozs.) each of essence of orange blossoms, essence of rose, and essence of mignonette, and 70 grammes (1.46 oz.) of tincture of vanilla, strain and color red or violet.

China-China.—Comminute 500 grammes (17.63 ozs.) of bitter almonds, 62 grammes (2.18 ozs.) of angelica seeds, and 4 grammes (0.141 oz.) of mace. Digest the ingredients in 9 kilogr. (19.8 lbs.) of alcohol of 22 per cent. for 14 days, distil until 7 kilogr. (15.4 lbs.) have passed over, compound the

distillate with 3.5 kilogr. (7.7 lbs.) of sugar syrup, 250 grammes (8.81 ozs.) of orange-blossom water, and 10 drops of essence of cinnamon, color with caramel, and strain.

Coquette flatteuse.—Comminute the peels of 8 cedrat citrons, 10 oranges and 10 lemons, 300 grammes (10.58 ozs.) of dried hyssop leaves and 60 grammes (2.11 ozs.) of musk roses. Digest the materials in 20 kilogr. (44 lbs.) of whiskey of 22 per cent. for 8 days, then distil and add the syrup from 8 kilogr. (17.6 lbs.) of sugar, color red and strain.

Domino.—Digest 90 grammes (3.17 ozs.) of fresh lemon peel, 45 grammes (1.58 oz.) each of calamus root and angelica root, 30 grammes (1.05 oz.) each of cinnamon and anise, 15 grammes (0.52 oz.) each of nutmeg, cloves, juniper berries and coriander, and 4 grammes (0.14 oz.) each of ginger and vanilla with 10 kilogr. (22 lbs.) of alcohol and 6 liters (1.58 gallon) of water for 2 days, distil until 12 kilogr. (26.4 lbs.) have passed over, compound the distillate with 3.5 kilogr. (7.7 lbs.) of sugar, and color dark red.

Eau de Berger.—Digest 240 grammes (8.46 ozs.) of orange peel, 180 grammes (6.34 ozs.) of cinnamon, 60 grammes (2.11 ozs.) of balm, and 30 grammes (1.05 oz.) each of cardamon and mace in 20 kilogr. (44 lbs.) of alcohol of 90 per cent. Tr., for some time; then distil off 18 kilogr. (39.6 lbs.) of liqueur, to which add 8 kilogr. (17.6 lbs.) of sugar dissolved

in 7 liters (1.85 gallon) of water, color red with cochineal and strain.

Eau de Chevalier de St. Louis.—Comminute 1 kilogr. (2.2 lbs.) each of almonds and peach kernels, and 500 grammes (1.1 lb.) each of bitter almonds and cherry kernels. Digest the materials in 20 liters (5.28 gallons) of whiskey of 22 per cent. for 8 days, then distil, sweeten the distillate with the syrup from 5 kilogr. (11 lbs.) of sugar, add 1.5 liter (3.16 pints) of rose-water, filter and color red.

Eau de Noyaux.—Comminute 1.5 kilogramme (3.3 lbs.) of apricot kernels, 0.5 kilogr. (1.1 lb.) of peach kernels, and 0.5 kilogr. (1.1 lb.) of plum kernels. Digest the materials in 30 kilogr. (66 lbs.) of spirit of 22 per cent. for 20 to 30 days, and then distil off 18 kilogr. (39.6 lbs.) Add to the distillate the syrup from 7.5 kilogr. (16.5 lbs.) of sugar and 8 liters (2.11 gallons) of water, and 2 liters (4.22 pints) of orange-blossom water, and filter.

Eau romaine.—Comminute 0.5 kilogr. (1.1 lb.) each of figs and dates, and 0.25 kilogr. (0.55 lb.) each of fresh lemon peel and orange peel. Digest the materials in 20 liters (5.28 gallons) of spirit of 22 per cent. and 16 liters (4.22 gallons) of water for 8 days; then distil off 18 liters (4.75 gallons), sweeten the distillate with the syrup from 8 kilogr. (17.6 lbs.) of sugar and 6 liters (1.58 gallon) of water, add 2 liters (4.22 pints) of orange blossom water, and filter.

Eau de vertu.—Comminute 185 grammes (6.52 ozs.) of juniper berries, 125 grammes (4.4 ozs.) each of lemon peel and of pomegranate peel, 92 grammes (3.24 ozs.) of rosemary leaves, 62 grammes (2.18 ozs.) each of rosewood and angelica root, 25 grammes (0.88 oz.) each of cloves and ginger, and 8 grammes (0.28 oz.) each of mastic and storax. Digest the materials in 22 kilogr. (48.4 lbs.) of alcohol and 18 liters (4.75 gallons) of water and distil off 19 kilogr. (41.8 lbs.). Add to the distillate 14 kilogr. (30.8 lbs.) of water and 12 kilogr. (26.4 lbs.) of sugar syrup, color violet and strain.

Eau de Zelia.—Comminute 62 grammes (2.18 ozs.) of lemon peel, 31 grammes (1.09 oz.) each of rosemary leaves, lavender blossoms, and cinnamon, and 16 grammes (0.56 oz.) each of cloves, mace, and badiane. Pour 22 kilog. (48.4 lbs.) of alcohol and 18 liters (4.75 gallons) of water over the ingredients, and after allowing the whole to digest in the heat for some time, distil off 19 kilog. (41.8 lbs.). Add to the distillate 50 drops of essence of vanilla, 2 liters (4.22 pints) each of rose-water, orange-blossom water, and balm water, 8 liters (2.11 gallons) of water, and 12 kilogr. (26.4 lbs.) of sugar syrup, color red and strain.

Eau de Paix.—Comminute separately 185 grammes (6.52 ozs.) each of pomegranate peel and lemon peel, 125 grammes (4.4 ozs.) each of rosemary blossoms, angelica root, and sweet almonds, and 31 grammes (1.09 oz.) each of cardamon,

badiane, nutmeg, cinnamon, and cloves, mix the ingredients, pour 22 kilogr. (48.4 lbs.) of alcohol and 18 liters (4.75 gallons) of water over them, and distil off 19 kilogr. (41.8 lbs.). Compound the distillate with 7 liters (1.85 gallon) of water, and 24 kilogr. (52.8 lbs.) of sugar syrup, color yellow and strain.

Gaité Française.—Comminute 16 grammes (0.56 oz.) each of cloves and cinnamon, 5 grammes (0.17 oz.) of cardamon and the peels of 3 lemons and of 3 oranges. Macerate the ingredients in whiskey for 14 days, then add 8 liters (2.11 gallons) of spirit of 22 per cent., and distil. Sweeten the distillate with a syrup prepared from 2.5 kilogr. (5.5 lbs.) of sugar, color red, and filter.

Genièvre.—Macerate 1 kilogr. (2.2 lbs.) of juniper berries in 8 kilogr. (17.6 lbs.) of alcohol and 3 liters (6.33 pints) of water for 2 days, then distil off 9 kilogr. (19.8 lbs.), compound the distillate with 1.5 kilogr. (3.3 lbs.) of sugar and filter.

Gold water liqueur. — Macerate 7.5 grammes (0.26 oz.) of powdered coriander, 15 grammes (0.52 oz.) of pulverized cinnamon, 4 grammes (0.14 oz.) of grated mace, 2 grammes (30.86 grains) of grated nutmeg, 15 grammes (0.52 oz.) of saffron, the yellow of the peel of 6 lemons, and 7.5 grammes (0.26 oz.) of carrot seeds in 6 liters (1.58 gallon) of spirit of wine of 30° B. for 8 days; then add 5.5 liters (1.45 gallon) of water, distil and filter the distillate.

Preparation of the syrup for this liqueur.—Dis-

solve 5.5 kilogr. (12.1 lbs.) of sugar in 5.5 liters (1.45 gallon) of pure water, add 15 grammes (0.52 oz.) of tincture of vanilla, clarify, color yellow with 7.5 grammes (0.26 oz.) of fine saffron and, after allowing the syrup to repose for 3 to 4 days, filter and then add it to the liqueur. Draw the liqueur into quart bottles and add to each bottle as much gold leaf rubbed fine as desired.

Nectar of the Gods.—Digest 125 grammes (4.4 ozs.) of white honey, 62 grammes (2.18 ozs.) of comminuted coriander, 31 grammes (1.09 oz.) of fresh lemon peel cut up, 250 grammes (8.81 ozs.) of powdered cloves, and 16 grammes (0.56 oz.) each of powdered storax and benzoin, in 6 kilogr. (13.2 lbs.) of spirit of wine of 33 per cent. for 14 days; then distil off 5.5 kilogr. (12.1 lbs.), compound the distillate with the syrup from 3 kilogr. (6.6 lbs.) of white sugar, 2 grammes (30.86 grains) of tincture of vanilla, and 92 grammes (3.24 ozs.) of essence of orange blossoms, color dark red, and strain.

Incomparable liqueur.—Comminute 30 grammes (1.05 oz.) of fresh lemon peel, 60 grammes (2.11 ozs.) of mace, 30 grammes (1.05 oz.) of lavender blossoms, 60 grammes (2.11 ozs.) each of balm, marjoram, and anise, 30 grammes (1.05 oz.) of coriander, and 15 grammes (0.52 oz.) each of mace and ginger. Pour 8 kilogr. (17.6 lbs.) of alcohol and 5 liters (1.32 gallon) of water over the materials, and after allowing them to digest for 2 days, distil off 9 kilogr. (19.8 lbs.). Compound the dis-

tillate with 3 kilogr. (6.6 lbs.) of sugar, and 4 grammes (0.14 oz.) of essence of orange blossoms and filter.

Calamus liqueur.—Comminute 300 grammes (10.58 ozs.) of calamus, 30 grammes (1.05 oz.) each of orris root and fennel, 7.5 grammes (0.26 oz.) of cardamon, and 4 grammes (0.14 oz.) of ginger. Pour 6 kilogr. (13.2 lbs.) of alcohol, and 2 liters (4.22 pints) of water over the materials, and after allowing them to digest for 2 days, distil off 6.5 kilogr. (14.3 lbs.), compound the distillate with 1.5 kilogr. (3.3 lbs.) of sugar, and filter.

Carminative.—Comminute 240 grammes (8.46 ozs.) of coriander, 180 grammes (6.34 ozs.) each of fennel and anise, 90 grammes (3.17 ozs.) of zedoary, 120 grammes (4.23 ozs.) each of fresh lemon peel, fresh orange peel, cinnamon, calamus, and orris root, 30 grammes (1.05 oz.) each of gentian, holy thistle and cardamon, and 7.5 grammes (0.26 oz.) of ginger. Pour 20 kilogr. (44 lbs.) of alcohol and 10 liters (2.64 gallons) of water over the materials and after allowing them to macerate 2 days, distil off 24 kilogr. (52.8 lbs.), and compound the distillate with 4 kilogr. (8.8 lbs.) of sugar.

Chartreuse.—Comminute 500 grammes (1.1 lb.) of fresh lemon peel, 250 grammes (8.81 ozs.) each of fresh pomegranate peel, dried hyssop blossoms, and peppermint, 125 grammes (4.4 ozs.) each of mountain wormwood and angelica seeds, 25 grammes (0.88 oz.) each of angelica root, cinnamon, mace,

cloves, and tonca bean, 50 grammes (1.76 oz.) of calamus root, and 10 grammes (0.35 oz.) of cardamon. Distil the materials with 50 liters (13.2 gallons) of spirit of 95 per cent. and 50 liters (13.2 gallons) of water. Collect the first and the last run by themselves so that only 45 liters (11.88 gallons) of chartreuse spirit are obtained, which is sweetened with a syrup prepared from 40 kilogr. (88 lbs.) of sugar, and 25 liters (6.6 gallons) of water. This liqueur is colored either yellow or green.

La felicité.—Comminute 16 grammes (0.56 oz.) each of cardamon and angelica root, 31 grammes (1.09 oz.) of orris root, 4 grammes (0.14 oz.) each of mace and Peruvian balsam, 8 grammes (0.28 oz.) of basil, and the peels of 8 lemons. Macerate the materials in spirit for 8 days, then digest them in a water-bath with 8 liters (2.11 gallons) of spirit of 22 per cent., add a syrup prepared from 2 kilogr. (4.4 lbs.) of sugar and the necessary water, color rose color, and filter.

Imperial liqueur.—Comminute 150 grammes (5.29 ozs.) of fresh hips (fruit of the dog rose), 60 grammes (2.11 ozs.) each of bay leaves, cinnamon, dill seed, thyme, balm, and juniper berries, and 30 grammes (1.05 oz.) each of chamomile, mace, and sage. Pour 20 kilogr. (44 lbs.) of spirit of wine and 16 liters (4.22 gallons) of water over the ingredients, and distil off 18 kilogr. (39.6 lbs.) Compound the distillate with 8 kilogr. (17.6 lbs.) of

sugar dissolved in 12 liters (3.17 gallons) of water, add 2 kilogr. (4.4 lbs.) of cinnamon water and filter.

Eau vert stomachique.—Comminute 120 grammes (4.23 ozs.) each of fresh lemon peel and angelica root, 90 grammes (3.17 ozs.) each of wormwood, centaury, and calamus root, 60 grammes (2.11 ozs.) each of common buck bean, balm, and curled mint, 30 grammes (1.05 oz.) each of badiane, cinnamon, cloves, coriander and rosemary, and 15 grammes (0.52 oz.) of mace. Pour 8 kilogr. (17.6 lbs.) of alcohol, and 3 liters (6.33 pints) of water over the materials, and after allowing them to macerate for 2 days, distil off 10 kilogr. (22 lbs.) and compound the distillate with 3 kilogr. (6.6 lbs.) of sugar. Color green and filter.

Michilimakinak.[1]—Convert into a fine powder 4 grammes (0.15 oz.) of mace, and 8 grammes (0 28 oz.) of cloves, and after digesting in 8 liters (2.11 gallons) of whiskey of 22 per cent., distil off 6 liters (1.58 gallon). Add to the distillate 10 drops of tincture of ambergris, 16 grammes (0.56 oz.) of essence of jasmine, and 0.5 liter (1.05 pint) each of rose-water and orange-blossom water, and sweeten with a syrup prepared from 500 grammes (1.1 lb.) of sugar and the necessary water.

Nectar du Générale Foy.—Make a cold syrup from 6 kilogr. (13.2 lbs.) of sugar, 4 liters (1.05

[1] The name of this liqueur is of Indian origin, and was given to it by a Russian fur dealer.

gallon) of rose-water, and 4 grammes (0.14 oz.) of tincture of vanilla. Compound the syrup with 2 kilogr. (4.4 lbs.) of alcohol of 36 per cent., and filter.

Nectar des Grécs.—Comminute the peels of 4 lemons, 62 grammes (2.18 ozs.) of roasted coffee, and 32 grammes (1.12 oz.) of cinnamon. Digest the materials in 10 kilogr. (22 lbs.) of whiskey of 22 per cent. for 8 days, then distil and compound the distillate with the syrup from 5 kilogr. (11 lbs.) of sugar, and 4 grammes (0.14 oz.) of tincture of vanilla. Color the liqueur red, and strain.

Nectar de la Beauté.—Comminute the peels of 4 lemons and 5 pomegranates, 92 grammes (3.24 ozs.) of cinnamon, 8 grammes (0.28 oz.) of mace, 125 grammes (4.4 ozs.) each of badiane and coriander, 62 grammes (2.18 ozs.) of juniper berries, 31 grammes (1.09 oz.) of angelica seed, and 4 grammes (0.14 oz.) of saffron. Pour 16 kilogr. (35.2 lbs.) of alcohol of 32 per cent. over the materials, and let the whole stand for four weeks; then distil off 2 kilogr. (4.4 lbs.) and add to the distillate a syrup prepared from 4.5 kilogr. (9.9 lbs.) of sugar, and 1 kilogr. (2.2 lbs.) of rose-water. Color the liqueur red, and strain.

Pour bon appetit.—Comminute 240 grammes (8.46 ozs.) each of angelica root and calamus, 120 grammes (4.23 ozs.) each of balm, chamomile, and origanum, 90 grammes (3.17 ozs.) each of marjoram and thyme, 60 grammes (2.11 ozs.) each of

anise, coriander, juniper berries, orris root, bay leaves, fresh orange peel, fresh lemon peel, wormwood, centaury, and peppermint, 30 grammes (1.05 oz.) each of cinnamon and cloves, 15 grammes (0.52 oz.) of mace, and 7.5 grammes (0.26 oz.) of cardamon. Macerate the materials in 12 kilogr. (26.4 lbs.) of alcohol and 5 liters (1.32 gallon) of water for 2 days; then distil off 14 kilogr. (30.8 lbs.), compound the distillate with 3.5 kilogr. (7.7 lbs.) of sugar, color with cherry juice and tincture of carmine, and filter.

Swiss liqueur.—Comminute 240 grammes (8.46 ozs.) of calamus root, 180 grammes (6.34 ozs.) of lemon peel, 120 grammes (4.23 ozs.) each of angelica root and wormwood, 90 grammes (3.17 ozs.) each of marjoram, balm, and orris root, 60 grammes (2.11 ozs.) each of thyme and badiane, 30 grammes (1.05 oz.) of ginger and 7.5 grammes (0.26 oz.) each of cardamon and mace. Macerate the materials in 10 kilogr. (22 lbs.) of alcohol, and 3 liters (6.33 pints) of water for 2 days; then distil off 11 kilogr. (24.2 lbs.) and sweeten the liqueur with 3 kilogr. (6.6 lbs.) of sugar.

Eau de la Sultane Zoraide.—Comminute 250 grammes (8.8 ozs.) each of lemon peel, pomegranate peel and figs, 125 grammes (4.4 ozs.) each of dates and jasmine flowers, and 52 grammes (1.83 oz.) of cinnamon. Digest the materials in 22 liters (5.81 gallons) of alcohol and 18 liters (4.75 gallons) of water for a few days; then distil off 19 liters

(5.02 gallons), compound the distillate with 2 liters (4.22 pints) of orange-blossom water, 12 liters (3.17 gallons) of pure water, and 12.5 kilogr. (27.5 lbs.) of sugar syrup, color red, and strain through a cloth.

Goutte nationale.—Digest in 4 kilogr. (8.8 lbs.) of whiskey of 22 per cent., for four weeks, the peels of 6 pomegranates, 31 grammes (1.09 oz.) each of coriander and sassafras, and 4 grammes (0.14 oz.) of cinnamon; then distil and add to the distillate the syrup from 1.5 kilogr. (3.3 lbs.) of sugar, color red, and strain through a cloth.

Hamburg bitters.—Macerate in 10 kilogr. (22 lbs.) of alcohol, and 6 liters (1.58 gallon) of water for 2 days, 120 grammes (4.23 ozs.) of cinnamon, 60 grammes (2.11 ozs.) each of quassia wood, wormwood, calamus, and centaury, 30 grammes (1.05 oz.) each of cloves, anise, coriander and orris root, and 7.5 grammes (0.26 oz.) each of mace, cardamon, and ginger. Then distil off 12 kilogr. (26.4 lbs.) compound the distillate with 2.75 kilogr. (6.05 lbs.) of sugar, color brown, and filter.

Eau nuptiale.—Comminute 185 grammes (6.52 ozs.) of parsley seed, 155 grammes (5.46 ozs.) of carrot seed, 62 grammes (2.18 ozs.) each of orris root, anise, and rosewood, and 48 grammes (1.69 oz.) of mace. Pour 22 kilogr. (48.4 lbs.) of alcohol, and 36 liters (9.5 gallons) of water over the materials, allow the whole to digest for some time, then

distil off 38 kilogr. (83.6 lbs.) add to the distillate 7 liters (1.85 gallon) of rose-water, 23 liters (6.07 gallons) of water, and 24 kilogr. (52.8 lbs.) of sugar syrup, and filter.

Coffee liqueur.—Distil 0.5 kilogr. (1.1 lb.) of ground roasted coffee with 6 liters (1.58 gallon) of water. To the distillate, amounting to about 4 kilogr. (8.8 lbs.), add 2 kilogr. (4.4 lbs.) of sugar, 6 kilogr. (13.2 lbs.) of spirit of wine of 85 per cent. and 60 grammes (2.11 ozs.) of vanilla sugar, and filter.

Cordial-water.—Comminute 1.5 kilogr. (3.3 lbs.) of fresh lemon peel, 155 grammes, (5.46 ozs.) of balm, 125 grammes (4.4 ozs.) each of anise and coriander, 250 grammes (8.8 ozs.) of cinnamon, 62 grammes (2.18 ozs.) of mace, and 31 grammes (1.09 oz.) of nutmeg. Digest the materials in 22 kilogr. (48.4 lbs.) of alcohol, and 18 liters (4.75 gallons) of water for a few days; then distil off 19 kilogr. (41.8 lbs.), sweeten the distillate with 12 kilogr. (26.4 lbs.) of sugar syrup, add 18 liters (4.75 gallons) of water, color blue and filter.

Strengthening liqueur.—Comminute 250 grammes (8.8 ozs.) of chamomiles, 185 grammes (6.52 ozs.) each of juniper berries and orange peel, 125 grammes (4.4 ozs.) of cinnamon, 31 grammes (1.09 oz.) of cloves, and 16 grammes (0.56 oz.) of cardamon. Digest the materials in 22 kilogr. (48.4 lbs.) of alcohol, and 18 liters (4.75 gallons) of water for some time, then distil off 19 kilogr. (41.8 lbs.), and

compound the distillate with 14 kilogr. (30.8 lbs.) of water, and a sufficient quantity of sugar.

Noah water.—Comminute 500 grammes (1.1 lb.) of toasted bread, 155 grammes (5.46 ozs.) of dried lemon peel, 62 grammes (2.18 ozs.) each of chamomile and juniper berries, and 31 grammes (1.09 oz.) of nutmeg. Pour 22 kilogr. (48.4 lbs.) of spirit of wine, and 18 liters (4.75 gallons), of water over the materials, distil off 20 kilogr. (44 lbs.), add to the distillate 17 kilogr. (37.4 lbs.) of sugar syrup, and 14 liters (3.7 gallons) of water, color red, strain, and add some comminuted silver leaf.

Orange liqueur.—Comminute 480 grammes (16.93 ozs.) of fresh orange peel, 240 grammes (8.46 ozs.) of unripe pomegranates, 120 grammes (4.23 ozs.) each of lemon peel and calamus, 60 grammes (2.11 ozs.) each of orris root and cinnamon flowers, 30 grammes (1.05 oz.) of cloves, and 7.5 grammes (0.26 oz.) of mace. Macerate the materials in 6 kilogr. (13.2 lbs.) of alcohol, and 2 liters (4.22 pints) of water for 2 days; then distil off 6.5 kilogr. (14.3 lbs.), add to the distillate 2 kilogr. (4.4 lbs.) of sugar, and filter.

Rosemary liqueur.—Comminute 480 grammes (16.93 ozs.) of rosemary, 60 grammes (2.11 ozs.) of marjoram, 30 grammes (1.05 oz.) of anise and 7.5 grammes (0.26 oz.) of mace. Macerate the materials in 4 kilogr. (8.8 lbs.) of alcohol and 1.5 liter (3.16 pints) of water for 2 days; then distil off 4.5

kilogr. (9.9 lbs.), sweeten the distillate with 1.5 kilogr. (3.3 lbs.) of sugar, and filter.

Rose liqueur.—Pour 15 kilogr. (33 lbs.) of alcohol and 8 liters (2.11 gallons) of water over 5 kilogr. (11 lbs.) of fresh rose leaves, and distil off 15 kilogr. (33 lbs.). Then dissolve 3 kilogr. (6.6 lbs.) of pulverized sugar in 5 kilogr. (11 lbs.) of cold water, add the solution to the distillate, color red with tincture of cochineal, and filter.

Vanilla liqueur.—Crush 4 good lemons, and convert into a coarse powder: 45 grammes (1.58 ozs.) of Ceylon cinnamon, 5 grammes (0.17oz.) of cloves, 5 grammes (0.17 oz.) of vanilla, and 300 grammes (10.58 ozs.) of dried cherries. Digest the substances in 2.5 kilogr. (5.5 lbs.) of good old whiskey for 8 days, then strain, and add 0.6 kilogr. (1.32 lb.) of sugar, and filter through filtering paper or felt.

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